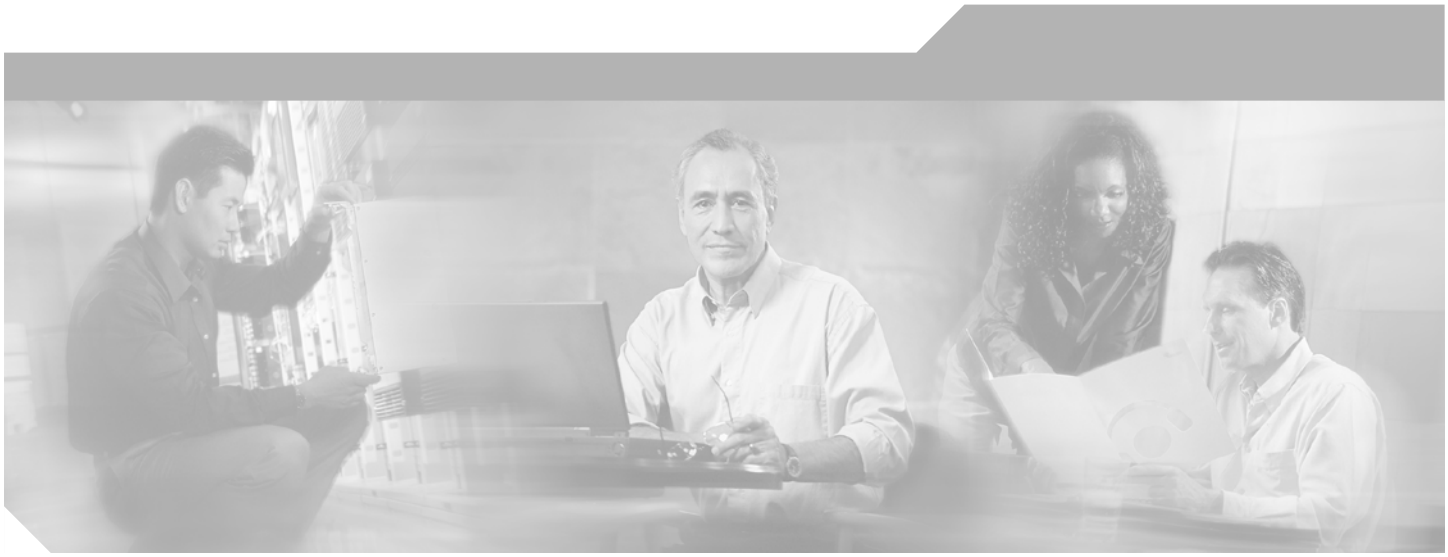

Cisco Wireless LAN Controller Configuration Guide

Software Release 3.2
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CONTENTS

Preface

This preface provides an overview of the *Cisco Wireless LAN Controller Configuration Guide* (OL-8335-02), references related publications, and explains how to obtain other documentation and technical assistance, if necessary. It contains these sections:

Audience

This guide describes Cisco Wireless LAN Controllers and Cisco Lightweight Access Points. This guide is for the networking professional who installs and manages these devices. To use this guide, you should be familiar with the concepts and terminology of wireless LANs.

Purpose

This guide provides the information you need to set up and configure wireless LAN controllers.

Organization

This guide is organized into these chapters:

Chapter 1, "Overview," provides an overview of the network roles and features of wireless LAN controllers.

Chapter 2, "Using the Web-Browser and CLI Interfaces," describes how to use the controller GUI and CLI.

Chapter 3, "Configuring Ports and Interfaces," describes the controller's physical ports and interfaces and provides instructions for configuring them.

Chapter 4, "Configuring Controller Settings," describes how to configure settings on the controllers.

Chapter 5, "Configuring Security Solutions," describes application-specific solutions for wireless LANs.

Chapter 6, "Configuring WLANs," describes how to configure wireless LANs and SSIDs on your system.

Chapter 7, "Controlling Lightweight Access Points," explains how to connect access points to the controller and manage access point settings.

Chapter 8, "Managing Controller Software and Configurations," describes how to upgrade and manage controller software and configurations.

Chapter 9, "Configuring Radio Resource Management," describes radio resource management (RRM) and explains how to configure it on the controllers.

Chapter 10, "Configuring Mobility Groups," describes mobility groups and explains how to configure them on the controllers.

Appendix A, "Safety Considerations and Translated Safety Warnings," lists safety considerations and translations of the safety warnings that apply to the Cisco Unified Wireless Network Solution products.

Appendix B, "Declarations of Conformity and Regulatory Information," provides declarations of conformity and regulatory information for the products in the Cisco Unified Wireless Network Solution.

Appendix C, "End User License and Warranty," describes the end user license and warranty that apply to the Cisco Unified Wireless Network Solution products.

Appendix D, "System Messages and Access Point LED Patterns," lists system messages that can appear on the Cisco Unified Wireless Network Solution interfaces and describes the LED patterns on lightweight access points.

Conventions

This publication uses these conventions to convey instructions and information:

Command descriptions use these conventions:

- Commands and keywords are in boldface text.
- Arguments for which you supply values are in italic.
- Square brackets ([ ]) mean optional elements.
- Braces ({ }) group required choices, and vertical bars (|) separate the alternative elements.
- Braces and vertical bars within square brackets ([{ | }]) mean a required choice within an optional element.

Interactive examples use these conventions:

- Terminal sessions and system displays are in `screen` font.
- Information you enter is in **`boldface screen`** font.
- Nonprinting characters, such as passwords or tabs, are in angle brackets (< >).

Notes, cautions, and timesavers use these conventions and symbols:

Tip Means the following will help you solve a problem. The tips information might not be troubleshooting or even an action, but could be useful information.

Note Means reader take note. Notes contain helpful suggestions or references to materials not contained in this manual.

Caution Means reader be careful. In this situation, you might do something that could result equipment damage or loss of data.

Warning **This warning symbol means danger. You are in a situation that could cause bodily injury. Before you work on any equipment, be aware of the hazards involved with electrical circuitry and be familiar with standard practices for preventing accidents. (To see translations of the warnings that appear in this publication, refer to the appendix "Translated Safety Warnings.")**

Waarschuwing **Dit waarschuwingssymbool betekent gevaar. U verkeert in een situatie die lichamelijk letsel kan veroorzaken. Voordat u aan enige apparatuur gaat werken, dient u zich bewust te zijn van de bij elektrische schakelingen betrokken risico's en dient u op de hoogte te zijn van standaard maatregelen om ongelukken te voorkomen. (Voor vertalingen van de waarschuwingen die in deze publicatie verschijnen, kunt u het aanhangsel "Translated Safety Warnings" (Vertalingen van veiligheidsvoorschriften) raadplegen.)**

Varoitus **Tämä varoitusmerkki merkitsee vaaraa. Olet tilanteessa, joka voi johtaa ruumiinvammaan. Ennen kuin työskentelet minkään laitteiston parissa, ota selvää sähkökytkentöihin liittyvistä vaaroista ja tavanomaisista onnettomuuksien ehkäisykeinoista. (Tässä julkaisussa esiintyvien varoitusten käännökset löydät liitteestä "Translated Safety Warnings" (käännetyt turvallisuutta koskevat varoitukset).)**

Attention **Ce symbole d'avertissement indique un danger. Vous vous trouvez dans une situation pouvant entraîner des blessures. Avant d'accéder à cet équipement, soyez conscient des dangers posés par les circuits électriques et familiarisez-vous avec les procédures courantes de prévention des accidents. Pour obtenir les traductions des mises en garde figurant dans cette publication, veuillez consulter l'annexe intitulée « Translated Safety Warnings » (Traduction des avis de sécurité).**

Warnung **Dieses Warnsymbol bedeutet Gefahr. Sie befinden sich in einer Situation, die zu einer Körperverletzung führen könnte. Bevor Sie mit der Arbeit an irgendeinem Gerät beginnen, seien Sie sich der mit elektrischen Stromkreisen verbundenen Gefahren und der Standardpraktiken zur Vermeidung von Unfällen bewußt. (Übersetzungen der in dieser Veröffentlichung enthaltenen Warnhinweise finden Sie im Anhang mit dem Titel "Translated Safety Warnings" (Übersetzung der Warnhinweise).)**

Avvertenza **Questo simbolo di avvertenza indica un pericolo. Si è in una situazione che può causare infortuni. Prima di lavorare su qualsiasi apparecchiatura, occorre conoscere i pericoli relativi ai circuiti elettrici ed essere al corrente delle pratiche standard per la prevenzione di incidenti. La traduzione delle avvertenze riportate in questa pubblicazione si trova nell'appendice, "Translated Safety Warnings" (Traduzione delle avvertenze di sicurezza).**

Advarsel **Dette varselsymbolet betyr fare. Du befinner deg i en situasjon som kan føre til personskade. Før du utfører arbeid på utstyr, må du være oppmerksom på de faremomentene som elektriske kretser innebærer, samt gjøre deg kjent med vanlig praksis når det gjelder å unngå ulykker. (Hvis du vil se oversettelser av de advarslene som finnes i denne publikasjonen, kan du se i vedlegget "Translated Safety Warnings" [Oversatte sikkerhetsadvarsler].)**

Aviso **Este símbolo de aviso indica perigo. Encontra-se numa situação que lhe poderá causar danos fisicos. Antes de começar a trabalhar com qualquer equipamento, familiarize-se com os perigos relacionados com circuitos eléctricos, e com quaisquer práticas comuns que possam prevenir possíveis acidentes. (Para ver as traduções dos avisos que constam desta publicação, consulte o apêndice "Translated Safety Warnings" - "Traduções dos Avisos de Segurança").**

¡Advertencia! **Este símbolo de aviso significa peligro. Existe riesgo para su integridad física. Antes de manipular cualquier equipo, considerar los riesgos que entraña la corriente eléctrica y familiarizarse con los procedimientos estándar de prevención de accidentes. (Para ver traducciones de las advertencias que aparecen en esta publicación, consultar el apéndice titulado "Translated Safety Warnings.")**

Varning! **Denna varningssymbol signalerar fara. Du befinner dig i en situation som kan leda till personskada. Innan du utför arbete på någon utrustning måste du vara medveten om farorna med elkretsar och känna till vanligt förfarande för att förebygga skador. (Se förklaringar av de varningar som förekommer i denna publikation i appendix "Translated Safety Warnings" [Översatta säkerhetsvarningar].)**

Related Publications

These documents provide complete information about the Cisco Unified Wireless Network Solution:

- *Cisco Wireless LAN Controller Command Reference*
- *Quick Start Guide*: *Cisco 2000 Series Wireless LAN Controllers*
- *Quick Start Guide*: *Cisco 4100 Series Wireless LAN Controllers*
- *Quick Start Guide*: *Cisco 4400 Series Wireless LAN Controllers*
- *Quick Start Guide: VPN Termination Module for Cisco 4400 Series Wireless LAN Controllers*
- *Quick Start Guide: VPN/Enhanced Security Modules for Cisco 4100 Series Wireless LAN Controllers*
- *Cisco Wireless Control System Configuration Guide*
- *Quick Start Guide: Cisco Wireless Control System for Microsoft Windows*
- *Quick Start Guide: Cisco Wireless Control System for Linux*
- *Quick Start Guide: Cisco Aironet 1000 Series Lightweight Access Points with Internal Antennas*
- *Quick Start Guide: Cisco Aironet 1000 Series Lightweight Access Points with External Antennas*

Click this link to browse to user documentation for the Cisco Unified Wireless Network Solution:

http://www.cisco.com/en/US/products/hw/wireless/tsd_products_support_category_home.html

Obtaining Documentation

Cisco documentation and additional literature are available on Cisco.com. Cisco also provides several ways to obtain technical assistance and other technical resources. These sections explain how to obtain technical information from Cisco Systems.

Cisco.com

You can access the most current Cisco documentation at this URL:

http://www.cisco.com/techsupport

You can access the Cisco website at this URL:

http://www.cisco.com

You can access international Cisco websites at this URL:

http://www.cisco.com/public/countries_languages.shtml

Product Documentation DVD

The Product Documentation DVD is a comprehensive library of technical product documentation on a portable medium. The DVD enables you to access multiple versions of installation, configuration, and command guides for Cisco hardware and software products. With the DVD, you have access to the same HTML documentation that is found on the Cisco website without being connected to the Internet. Certain products also have .PDF versions of the documentation available.

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Documentation Feedback

You can rate and provide feedback about Cisco technical documents by completing the online feedback form that appears with the technical documents on Cisco.com.

You can submit comments about Cisco documentation by using the response card (if present) behind the front cover of your document or by writing to the following address:

Cisco Systems
Attn: Customer Document Ordering
170 West Tasman Drive
San Jose, CA 95134-9883

We appreciate your comments.

Cisco Product Security Overview

Cisco provides a free online Security Vulnerability Policy portal at this URL:

http://www.cisco.com/en/US/products/products_security_vulnerability_policy.html

From this site, you will find information about how to:

- Report security vulnerabilities in Cisco products.
- Obtain assistance with security incidents that involve Cisco products.
- Register to receive security information from Cisco.

A current list of security advisories, security notices, and security responses for Cisco products is available at this URL:

http://www.cisco.com/go/psirt

To see security advisories, security notices, and security responses as they are updated in real time, you can subscribe to the Product Security Incident Response Team Really Simple Syndication (PSIRT RSS) feed. Information about how to subscribe to the PSIRT RSS feed is found at this URL:

http://www.cisco.com/en/US/products/products_psirt_rss_feed.html

Reporting Security Problems in Cisco Products

Cisco is committed to delivering secure products. We test our products internally before we release them, and we strive to correct all vulnerabilities quickly. If you think that you have identified a vulnerability in a Cisco product, contact PSIRT:

- For Emergencies only—security-alert@cisco.com

  An emergency is either a condition in which a system is under active attack or a condition for which a severe and urgent security vulnerability should be reported. All other conditions are considered nonemergencies.
- For Nonemergencies—psirt@cisco.com

In an emergency, you can also reach PSIRT by telephone:

- 1 877 228-7302
- 1 408 525-6532

Tip We encourage you to use Pretty Good Privacy (PGP) or a compatible product (for example, GnuPG) to encrypt any sensitive information that you send to Cisco. PSIRT can work with information that has been encrypted with PGP versions 2.*x* through 9.*x*.

Never use a revoked or an expired encryption key. The correct public key to use in your correspondence with PSIRT is the one linked in the Contact Summary section of the Security Vulnerability Policy page at this URL:

http://www.cisco.com/en/US/products/products_security_vulnerability_policy.html

The link on this page has the current PGP key ID in use.

If you do not have or use PGP, contact PSIRT at the aforementioned e-mail addresses or phone numbers before sending any sensitive material to find other means of encrypting the data.

Obtaining Technical Assistance

Cisco Technical Support provides 24-hour-a-day award-winning technical assistance. The Cisco Technical Support & Documentation website on Cisco.com features extensive online support resources. In addition, if you have a valid Cisco service contract, Cisco Technical Assistance Center (TAC) engineers provide telephone support. If you do not have a valid Cisco service contract, contact your reseller.

Cisco Technical Support & Documentation Website

The Cisco Technical Support & Documentation website provides online documents and tools for troubleshooting and resolving technical issues with Cisco products and technologies. The website is available 24 hours a day, at this URL:

http://www.cisco.com/techsupport

Access to all tools on the Cisco Technical Support & Documentation website requires a Cisco.com user ID and password. If you have a valid service contract but do not have a user ID or password, you can register at this URL:

http://tools.cisco.com/RPF/register/register.do

Note Use the Cisco Product Identification (CPI) tool to locate your product serial number before submitting a web or phone request for service. You can access the CPI tool from the Cisco Technical Support & Documentation website by clicking the **Tools & Resources** link under Documentation & Tools. Choose **Cisco Product Identification Tool** from the Alphabetical Index drop-down list, or click the **Cisco Product Identification Tool** link under Alerts & RMAs. The CPI tool offers three search options: by product ID or model name; by tree view; or for certain products, by copying and pasting **show** command output. Search results show an illustration of your product with the serial number label location highlighted. Locate the serial number label on your product and record the information before placing a service call.

Submitting a Service Request

Using the online TAC Service Request Tool is the fastest way to open S3 and S4 service requests. (S3 and S4 service requests are those in which your network is minimally impaired or for which you require product information.) After you describe your situation, the TAC Service Request Tool provides recommended solutions. If your issue is not resolved using the recommended resources, your service request is assigned to a Cisco engineer. The TAC Service Request Tool is located at this URL:

http://www.cisco.com/techsupport/servicerequest

For S1 or S2 service requests, or if you do not have Internet access, contact the Cisco TAC by telephone. (S1 or S2 service requests are those in which your production network is down or severely degraded.) Cisco engineers are assigned immediately to S1 and S2 service requests to help keep your business operations running smoothly.

To open a service request by telephone, use one of the following numbers:

Asia-Pacific: +61 2 8446 7411 (Australia: 1 800 805 227)
EMEA: +32 2 704 55 55
USA: 1 800 553-2447

For a complete list of Cisco TAC contacts, go to this URL:

http://www.cisco.com/techsupport/contacts

Definitions of Service Request Severity

To ensure that all service requests are reported in a standard format, Cisco has established severity definitions.

Severity 1 (S1)—An existing network is down, or there is a critical impact to your business operations. You and Cisco will commit all necessary resources around the clock to resolve the situation.

Severity 2 (S2)—Operation of an existing network is severely degraded, or significant aspects of your business operations are negatively affected by inadequate performance of Cisco products. You and Cisco will commit full-time resources during normal business hours to resolve the situation.

Severity 3 (S3)—Operational performance of the network is impaired, while most business operations remain functional. You and Cisco will commit resources during normal business hours to restore service to satisfactory levels.

Severity 4 (S4)—You require information or assistance with Cisco product capabilities, installation, or configuration. There is little or no effect on your business operations.

Obtaining Additional Publications and Information

Information about Cisco products, technologies, and network solutions is available from various online and printed sources.

- The *Cisco Product Quick Reference Guide* is a handy, compact reference tool that includes brief product overviews, key features, sample part numbers, and abbreviated technical specifications for many Cisco products that are sold through channel partners. It is updated twice a year and includes the latest Cisco offerings. To order and find out more about the Cisco Product Quick Reference Guide, go to this URL:

  http://www.cisco.com/go/guide

- Cisco Marketplace provides a variety of Cisco books, reference guides, documentation, and logo merchandise. Visit Cisco Marketplace, the company store, at this URL:

  http://www.cisco.com/go/marketplace/

- *Cisco Press* publishes a wide range of general networking, training and certification titles. Both new and experienced users will benefit from these publications. For current Cisco Press titles and other information, go to Cisco Press at this URL:

  http://www.ciscopress.com

- *Packet* magazine is the Cisco Systems technical user magazine for maximizing Internet and networking investments. Each quarter, Packet delivers coverage of the latest industry trends, technology breakthroughs, and Cisco products and solutions, as well as network deployment and troubleshooting tips, configuration examples, customer case studies, certification and training information, and links to scores of in-depth online resources. You can access Packet magazine at this URL:

  http://www.cisco.com/packet

- *iQ Magazine* is the quarterly publication from Cisco Systems designed to help growing companies learn how they can use technology to increase revenue, streamline their business, and expand services. The publication identifies the challenges facing these companies and the technologies to help solve them, using real-world case studies and business strategies to help readers make sound technology investment decisions. You can access iQ Magazine at this URL:

  http://www.cisco.com/go/iqmagazine

  or view the digital edition at this URL:

  http://ciscoiq.texterity.com/ciscoiq/sample/

- *Internet Protocol Journal* is a quarterly journal published by Cisco Systems for engineering professionals involved in designing, developing, and operating public and private internets and intranets. You can access the Internet Protocol Journal at this URL:

  http://www.cisco.com/ipj

- Networking products offered by Cisco Systems, as well as customer support services, can be obtained at this URL:

  http://www.cisco.com/en/US/products/index.html

- Networking Professionals Connection is an interactive website for networking professionals to share questions, suggestions, and information about networking products and technologies with Cisco experts and other networking professionals. Join a discussion at this URL:

  http://www.cisco.com/discuss/networking

- World-class networking training is available from Cisco. You can view current offerings at this URL:

  http://www.cisco.com/en/US/learning/index.html

Overview

This chapter describes the controller components and features. Its contains these sections:

Cisco Wireless LAN Solution Overview

The Cisco Wireless LAN Solution is designed to provide 802.11 wireless networking solutions for enterprises and service providers. The Cisco Wireless LAN Solution simplifies deploying and managing large-scale wireless LANs and enables a unique best-in-class security infrastructure. The operating system manages all data client, communications, and system administration functions, performs Radio Resource Management (RRM) functions, manages system-wide mobility policies using the operating system Security solution, and coordinates all security functions using the operating system security framework.

The Cisco Wireless LAN Solution consists of Cisco Wireless LAN Controllers and their associated lightweight access points controlled by the operating system, all concurrently managed by any or all of the operating system user interfaces:

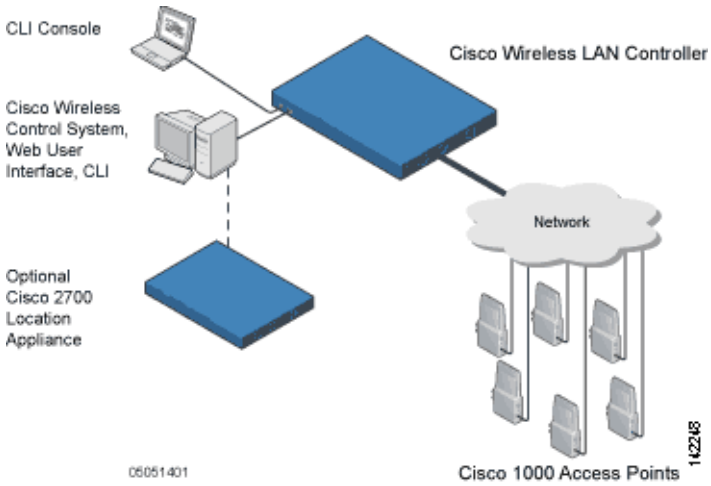
- An HTTP and/or HTTPS full-featured Web User Interface hosted by Cisco Wireless LAN Controllers can be used to configure and monitor individual controllers. See the "Web User Interface and the CLI" section on page 1-25.
- A full-featured command-line interface (CLI) can be used to configure and monitor individual Cisco Wireless LAN Controllers. See the "Web User Interface and the CLI" section on page 1-25.
- The Cisco Wireless Control System (WCS), which you use to configure and monitor one or more Cisco Wireless LAN Controllers and associated access points. WCS has tools to facilitate large-system monitoring and control. WCS runs on Windows 2000, Windows 2003, and Red Hat Enterprise Linux ES servers.
- An industry-standard SNMP V1, V2c, and V3 interface can be used with any SNMP-compliant third-party network management system.

The Cisco Wireless LAN Solution supports client data services, client monitoring and control, and all rogue access point detection, monitoring, and containment functions. The Cisco Wireless LAN Solution uses lightweight access points, Cisco Wireless LAN Controllers, and the optional Cisco WCS to provide wireless services to enterprises and service providers.

Note This document refers to Cisco Wireless LAN Controllers throughout. Unless specifically called out, the descriptions herein apply to all Cisco Wireless LAN Controllers, including but not limited to Cisco 2000 Series Wireless LAN Controllers, Cisco 4100 Series Wireless LAN Controllers, Cisco 4400 Series Wireless LAN Controllers, and the controllers on the Wireless Services Module (WiSM).

Figure 1-1 shows the Cisco Wireless LAN Solution components, which can be simultaneously deployed across multiple floors and buildings.

Figure 1-1 Cisco WLAN Solution Components



Single-Controller Deployments

A standalone controller can support lightweight access points across multiple floors and buildings simultaneously, and supports the following features:

- Autodetecting and autoconfiguring lightweight access points as they are added to the network.
- Full control of lightweight access points.
- Full control of up to 16 wireless LAN (SSID) policies for Cisco 1000 series access points.

Note LWAPP-enabled access points support up to 8 wireless LAN (SSID) policies.

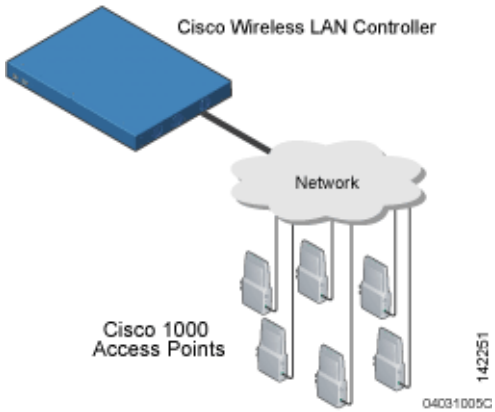
- Lightweight access points connect to controllers through the network. The network equipment may or may not provide Power over Ethernet to the access points.

Note that some controllers use redundant Gigabit Ethernet connections to bypass single network failures.

Note Some controllers can connect through multiple physical ports to multiple subnets in the network. This feature can be helpful when Cisco WLAN Solution operators want to confine multiple VLANs to separate subnets.

Figure 1-2 shows a typical single-controller deployment.

Figure 1-2 Single-Controller Deployment



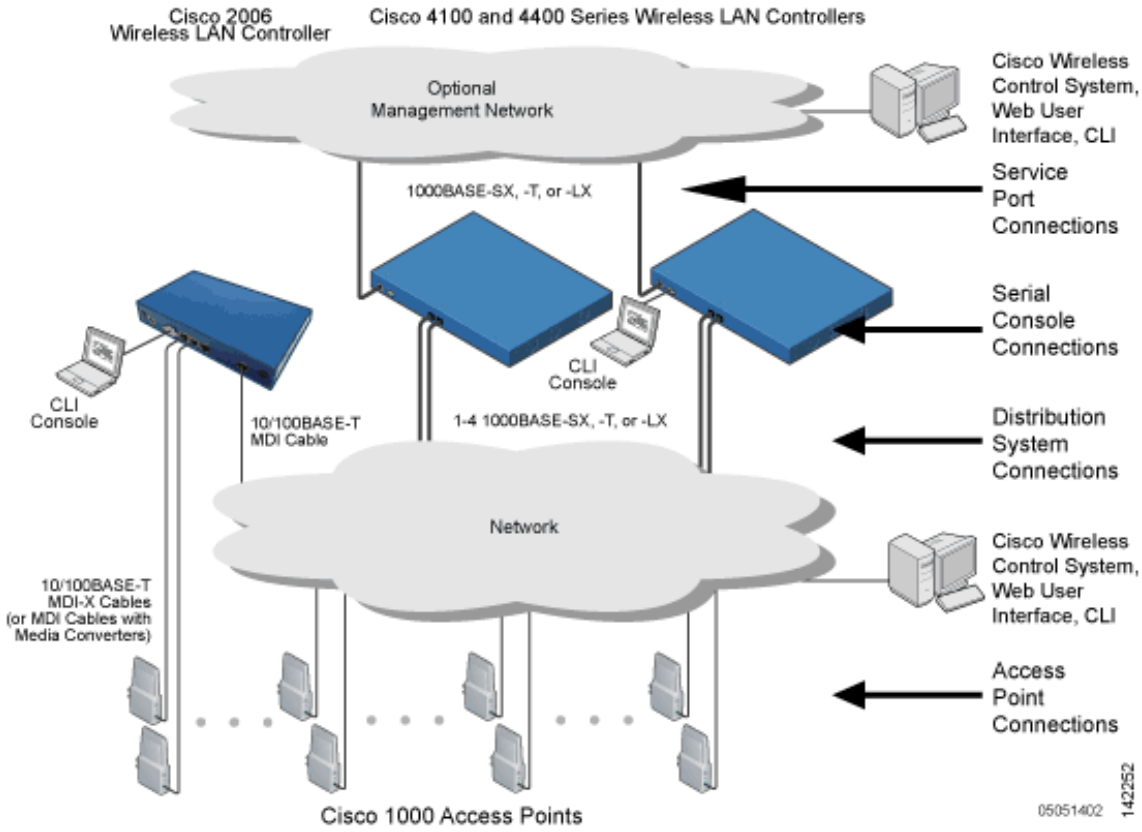
Multiple-Controller Deployments

Each controller can support lightweight access points across multiple floors and buildings simultaneously. However, full functionality of the Cisco Wireless LAN Solution is realized when it includes multiple controllers. A multiple-controller system has the following additional features:

- Autodetecting and autoconfiguring RF parameters as the controllers are added to the network.
- Same-Subnet (Layer 2) Roaming and Inter-Subnet (Layer 3) Roaming.
- Automatic access point failover to any redundant controller with a reduced access point load (refer to the "Cisco Wireless LAN Controller Failover Protection" section on page 1-20).

The following figure shows a typical multiple-controller deployment. The figure also shows an optional dedicated Management Network and the three physical connection types between the network and the controllers.

Figure 1-3 Typical Multi-Controller Deployment



Operating System Software

The operating system software controls Cisco Wireless LAN Controllers and Cisco 1000 Series Lightweight Access Points. It includes full operating system security and Radio Resource Management (RRM) features.

Operating System Security

Operating system security bundles Layer 1, Layer 2, and Layer 3 security components into a simple, Cisco WLAN Solution-wide policy manager that creates independent security policies for each of up to 16 wireless LANs. (Refer to the "Cisco WLAN Solution Wireless LANs" section on page 1-11.)

The 802.11 Static WEP weaknesses can be overcome using robust industry-standard security solutions, such as:

- 802.1X dynamic keys with extensible authentication protocol (EAP).
- Wi-Fi protected access (WPA) dynamic keys. The Cisco WLAN Solution WPA implementation includes:
  - Temporal key integrity protocol (TKIP) + message integrity code checksum (Michael) dynamic keys, or
  - WEP keys, with or without Pre-Shared key Passphrase.

- RSN with or without Pre-Shared key.
- Cranite FIPS140-2 compliant passthrough.
- Fortress FIPS140-2 compliant passthrough.
- Optional MAC Filtering.

The WEP problem can be further solved using industry-standard Layer 3 security solutions, such as:

- Terminated and passthrough VPNs
- Terminated and passthrough Layer Two Tunneling Protocol (L2TP), which uses the IP Security (IPSec) protocol.
- Terminated and pass-through IPSec protocols. The terminated Cisco WLAN Solution IPSec implementation includes:
  - Internet key exchange (IKE)
  - Diffie-Hellman (DH) groups, and
  - Three optional levels of encryption: DES (ANSI X.3.92 data encryption standard), 3DES (ANSI X9.52-1998 data encryption standard), or AES/CBC (advanced encryption standard/cipher block chaining).

  The Cisco WLAN Solution IPSec implementation also includes industry-standard authentication using:
  - Message digest algorithm (MD5), or
  - Secure hash algorithm-1 (SHA-1)
- The Cisco Wireless LAN Solution supports local and RADIUS MAC Address filtering.
- The Cisco Wireless LAN Solution supports local and RADIUS user/password authentication.
- The Cisco Wireless LAN Solution also uses manual and automated Disabling to block access to network services. In manual Disabling, the operator blocks access using client MAC addresses. In automated Disabling, which is always active, the operating system software automatically blocks access to network services for an operator-defined period of time when a client fails to authenticate for a fixed number of consecutive attempts. This can be used to deter brute-force login attacks.

These and other security features use industry-standard authorization and authentication methods to ensure the highest possible security for your business-critical wireless LAN traffic.

Cisco WLAN Solution Wired Security

Many traditional access point vendors concentrate on security for the Wireless interface similar to that described in the "Operating System Security" section on page 1-5. However, for secure Cisco Wireless LAN Controller Service Interfaces, Cisco Wireless LAN Controller to access point, and inter-Cisco Wireless LAN Controller communications during device servicing and client roaming, the operating system includes built-in security.

Each Cisco Wireless LAN Controller and Cisco 1000 series lightweight access point is manufactured with a unique, signed X.509 certificate. This certificate is used to authenticate IPSec tunnels between devices. These IPSec tunnels ensure secure communications for mobility and device servicing.

Cisco Wireless LAN Controllers and Cisco 1000 series lightweight access points also use the signed certificates to verify downloaded code before it is loaded, ensuring that hackers do not download malicious code into any Cisco Wireless LAN Controller or Cisco 1000 series lightweight access point.

Layer 2 and Layer 3 LWAPP Operation

The LWAPP communications between Cisco Wireless LAN Controller and Cisco 1000 series lightweight access points can be conducted at ISO Data Link Layer 2 or Network Layer 3.

Note The IPv4 network layer protocol is supported for transport through an LWAPP controller system. IPv6 (for clients only) and Appletalk are also supported but only on 4400 series controllers and the Cisco WiSM. Other Layer 3 protocols (such as IPX, DECnet Phase IV, OSI CLNP, and so on) and Layer 2 (bridged) protocols (such as LAT and NetBeui) are not supported.

Operational Requirements

The requirement for Layer 2 LWAPP communications is that the Cisco Wireless LAN Controller and Cisco 1000 series lightweight access points must be connected to each other through Layer 2 devices on the same subnet. This is the default operational mode for the Cisco Wireless LAN Solution. Note that when the Cisco Wireless LAN Controller and Cisco 1000 series lightweight access points are on different subnets, these devices must be operated in Layer 3 mode.

The requirement for Layer 3 LWAPP communications is that the Cisco Wireless LAN Controllers and Cisco 1000 series lightweight access points can be connected through Layer 2 devices on the same subnet, or connected through Layer 3 devices across subnets.

Note that all Cisco Wireless LAN Controllers in a mobility group must use the same LWAPP Layer 2 or Layer 3 mode, or you will defeat the Mobility software algorithm.

Configuration Requirements

When you are operating the Cisco Wireless LAN Solution in Layer 2 mode, you must configure a management interface to control your Layer 2 communications.

When you are operating the Cisco Wireless LAN Solution in Layer 3 mode, you must configure an AP-manager interface to control Cisco 1000 series lightweight access points and a management interface as configured for Layer 2 mode.

Cisco Wireless LAN Controllers

When you are adding Cisco 1000 series lightweight access points to a multiple Cisco Wireless LAN Controller deployments network, it is convenient to have all Cisco 1000 series lightweight access points associate with one master controller on the same subnet. That way, the operator does not have to log into multiple controllers to find out which controller newly-added Cisco 1000 series lightweight access points associated with.

One controller in each subnet can be assigned as the master controller while adding lightweight access points. As long as a master controller is active on the same subnet, all new access points without a primary, secondary, and tertiary controller assigned automatically attempt to associate with the master Cisco Wireless LAN Controller. This process is described in the "Cisco Wireless LAN Controller Failover Protection" section on page 1-20.

The operator can monitor the master controller using the WCS Web User Interface and watch as access points associate with the master controller. The operator can then verify access point configuration and assign a primary, secondary, and tertiary controller to the access point, and reboot the access point so it reassociates with its primary, secondary, or tertiary controller.

Note Lightweight access points without a primary, secondary, and tertiary controller assigned always search for a master controller first upon reboot. After adding lightweight access points through the master controller, assign primary, secondary, and tertiary controllers to each access point. Cisco recommends that you disable the master setting on all controllers after initial configuration.

Primary, Secondary, and Tertiary Controllers

In multiple-controller networks, lightweight access points can associate with any controller on the same subnet. To ensure that each access point associates with a particular controller, the operator can assign primary, secondary, and tertiary controllers to the access point.

When a primed access point is added to a network, it looks for its primary, secondary, and tertiary controllers first, then a master controller, then the least-loaded controller with available access point ports. Refer to the "Cisco Wireless LAN Controller Failover Protection" section on page 1-20 for more information.

Client Roaming

The Cisco Wireless LAN Solution supports seamless client roaming across Cisco 1000 series lightweight access points managed by the same Cisco Wireless LAN Controller, between Cisco Wireless LAN Controllers in the same Cisco WLAN Solution Mobility Group on the same subnet, and across controllers in the same Mobility Group on different subnets.

Same-Subnet (Layer 2) Roaming

Each Cisco Wireless LAN Controller supports same-controller client roaming across access points managed by the same controller. This roaming is transparent to the client as the session is sustained and the client continues using the same DHCP-assigned or client-assigned IP Address. The controller provides DHCP functionality with a relay function. Same-controller roaming is supported in single-controller deployments and in multiple-controller deployments.

Inter-Controller (Layer 2) Roaming

In multiple-controller deployments, the Cisco Wireless LAN Solution supports client roaming across access points managed by controllers in the same mobility group and on the same subnet. This roaming is also transparent to the client, as the session is sustained and a tunnel between controllers allows the client to continue using the same DHCP- or client-assigned IP Address as long as the session remains active. Note that the tunnel is torn down and the client must reauthenticate when the client sends a DHCP Discover with a 0.0.0.0 client IP Address or a 169.254.*.* client auto-IP Address, or when the operator-set session timeout is exceeded.

Note that the Cisco 1030 remote edge lightweight access points at a remote location must be on the same subnet to support roaming.

Inter-Subnet (Layer 3) Roaming

In multiple-controller deployments, the Cisco Wireless LAN Solution supports client roaming across access points managed by controllers in the same mobility group on different subnets. This roaming is transparent to the client, because the session is sustained and a tunnel between the controllers allows the client to continue using the same DHCP-assigned or client-assigned IP Address as long as the session remains active. Note that the tunnel is torn down and the client must reauthenticate when the client sends a DHCP Discover with a 0.0.0.0 client IP Address or a 169.254.*.* client auto-IP Address or when the operator-set user timeout is exceeded.

Note that the Cisco 1030 remote edge lightweight access points at a remote location must be on the same subnet to support roaming.

Special Case: Voice Over IP Telephone Roaming

802.11 VoIP telephones actively seek out associations with the strongest RF signal to ensure best Quality of Service (QoS) and maximum throughput. The minimum VoIP telephone requirement of 20 millisecond or shorter latency time for the roaming handover is easily met by the Cisco Wireless LAN Solution, which has an average handover latency of nine or fewer milliseconds.

This short latency period is controlled by Cisco Wireless LAN Controllers, rather than allowing independent access points to negotiate roaming handovers.

The Cisco Wireless LAN Solution supports 802.11 VoIP telephone roaming across Cisco 1000 series lightweight access points managed by Cisco Wireless LAN Controllers on different subnets, as long as the controllers are in the same mobility group. This roaming is transparent to the VoIP telephone, because the session is sustained and a tunnel between controllers allows the VoIP telephone to continue using the same DHCP-assigned IP Address as long as the session remains active. Note that the tunnel is torn down and the VoIP client must reauthenticate when the VoIP telephone sends a DHCP Discover with a 0.0.0.0 VoIP telephone IP Address or a 169.254.*.* VoIP telephone auto-IP Address or when the operator-set user timeout is exceeded.

Client Location

When you use Cisco WCS in your Cisco Wireless LAN Solution, controllers periodically determine client, rogue access point, rogue access point client, radio frequency ID (RFID) tag location and store the locations in the Cisco WCS database. For more information on location solutions, refer to the *Cisco Wireless Control System Configuration Guide* and the *Cisco Location Appliance Configuration Guide* at these URLs:

Cisco Wireless Control System Configuration Guide:

http://www.cisco.com/en/US/products/ps6305/products_installation_and_configuration_guides_list.html

Cisco Location Appliance Configuration Guide:

http://www.cisco.com/en/US/products/ps6386/products_installation_and_configuration_guides_list.html

External DHCP Servers

The operating system is designed to appear as a DHCP Relay to the network and as a DHCP Server to clients with industry-standard external DHCP Servers that support DHCP Relay. This means that each Cisco Wireless LAN Controller appears as a DHCP Relay agent to the DHCP Server. This also means that the Cisco Wireless LAN Controller appears as a DHCP Server at the virtual IP Address to wireless clients.

Because the Cisco Wireless LAN Controller captures the client IP Address obtained from a DHCP Server, it maintains the same IP Address for that client during same-Cisco Wireless LAN Controller, inter-Cisco Wireless LAN Controller, and inter-subnet client roaming.

Per-Wireless LAN Assignment

All Cisco WLAN Solution wireless LANs can be configured to use the same or different DHCP Servers, or no DHCP Server. This allows operators considerable flexibility in configuring their Wireless LANs, as further described in the "Cisco WLAN Solution Wireless LANs" section on page 1-11.

Note that Cisco WLAN Solution wireless LANs that support management over wireless must allow the management (device servicing) clients to obtain an IP Address from a DHCP Server. See the"Using Management over Wireless" section on page 5-6 for instructions on configuring management over wireless.

Per-Interface Assignment

You can assign DHCP servers for individual interfaces. The Layer 2 management interface, Layer 3 AP-manager interface, and dynamic interfaces can be configured for a primary and secondary DHCP server, and the service-port interface can be configured to enable or disable DHCP servers.

Note Refer to Chapter 3 for information on configuring the controller's interfaces.

Security Considerations

For enhanced security, Cisco recommends that operators require all clients to obtain their IP Addresses from a DHCP server. To enforce this requirement, all wireless LANs can be configured with a DHCP Required setting and a valid DHCP Server IP Address, which disallows client static IP Addresses. If a client associating with a wireless LAN with DHCP Required set does not obtain its IP Address from the designated DHCP Server, it is not allowed access to any network services.

Note that if DHCP Required is selected, clients must obtain an IP address via DHCP. Any client with a static IP address will not be allowed on the network. The Cisco Wireless LAN Controller monitors DHCP traffic because it acts as a DHCP proxy for the clients.

If slightly less security is tolerable, operators can create wireless LANs with DHCP Required disabled and a valid DHCP Server IP Address. Clients then have the option of using a static IP Address or obtaining an IP Address from the designated DHCP Server.

Operators are also allowed to create separate wireless LANs with DHCP Required disabled and a DHCP Server IP Address of 0.0.0.0. These wireless LANs drop all DHCP requests and force clients to use a static IP Address. Note that these wireless LANs do not support management over wireless connections.

Cisco WLAN Solution Wired Connections

The Cisco Wireless LAN Solution components communicate with each other using industry-standard Ethernet cables and connectors. The following paragraphs contain details of the Cisco WLAN Solution wired connections.

- The Cisco 2000 Series Wireless LAN Controller connects to the network using from one to four 10/100BASE-T Ethernet cables.
- The Cisco 4100 Series Wireless LAN Controller connects to the network using one or two fiber-optic Gigabit Ethernet cables: two redundant Gigabit Ethernet connections to bypass single network failures.
- The Cisco 4402 Wireless LAN Controller connects to the network using one or two fiber-optic Gigabit Ethernet cables, and the 4404 Wireless LAN Controller connects to the network using up to four fiber-optic Gigabit Ethernet cables: two redundant Gigabit Ethernet connections to bypass single network failures.
- The controllers on the Wireless Services Module (WiSM), installed in a Cisco Catalyst 6500 Series Switch, connect to the network through switch ports on the switch.
- The Wireless LAN Controller Network Module, installed in a Cisco Integrated Services Router, connects to the network through the ports on the router.
- Cisco 1000 series lightweight access points connects to the network using 10/100BASE-T Ethernet cables. The standard CAT-5 cable can also be used to conduct power for the Cisco 1000 series lightweight access points from a network device equipped with Power over Ethernet (PoE) capability. This power distribution plan can be used to reduce the cost of individual AP power supplies and related cabling.

Cisco WLAN Solution Wireless LANs

The Cisco Wireless LAN Solution can control up to 16 Wireless LANs for lightweight access points. Each wireless LAN has a separate wireless LAN ID (1 through 16), a separate wireless LAN SSID (wireless LAN name), and can be assigned unique security policies. Using software release 3.2 and later you can configure both static and dynamic WEP on the same wireless LAN.

The Cisco 1000 series lightweight access points broadcast all active Cisco WLAN Solution wireless LAN SSIDs and enforce the policies defined for each wireless LAN.

Note Cisco recommends that you assign one set of VLANs for wireless LANs and a different set of VLANs for management interfaces to ensure that controllers operate with optimum performance and ease of management.

If management over wireless is enabled across Cisco Wireless LAN Solution, the Cisco Wireless LAN Solution operator can manage the System across the enabled wireless LAN using CLI and Telnet, http/https, and SNMP.

To configure the Cisco WLAN Solution wireless LANs, refer to Chapter 6, “Configuring WLANs.”

Access Control Lists

The operating system allows you to define up to 64 Access Control Lists (ACLs), similar to standard firewall Access Control Lists. Each ACL can have up to 64 Rules (filters).

Operators can use ACLs to control client access to multiple VPN servers within a given wireless LAN. If all the clients on a wireless LAN must access a single VPN server, use the IPSec/VPN Gateway Passthrough setting, described in the "Security Overview" section on page 5-2.

After they are defined, the ACLs can be applied to the management interface, the AP-Manager interface, or any of the operator-defined interfaces.

Refer to Access Control Lists > New in the *Web User Interface Online Help* for instructions on configuring Access Control Lists.

Identity Networking

Cisco Wireless LAN Controllers can have the following parameters applied to all clients associating with a particular wireless LAN: QoS, global or Interface-specific DHCP server, Layer 2 and Layer 3 Security Policies, and default Interface (which includes physical port, VLAN and ACL assignments).

However, the Cisco Wireless LAN Controller can also have individual clients (MAC addresses) override the preset wireless LAN parameters by using MAC Filtering or by Allowing AAA Override parameters. This configuration can be used, for example, to have all company clients log into the corporate wireless LAN, and then have clients connect using different QoS, DHCP server, Layer 2 and Layer 3 Security Policies, and Interface (which includes physical port, VLAN and ACL assignments) settings on a per-MAC Address basis.

When Cisco Wireless LAN Solution operators configure MAC Filtering for a client, they can assign a different VLAN to the MAC Address, which can be used to have operating system automatically reroute the client to the management interface or any of the operator-defined interfaces, each of which have their own VLAN, ACL, DHCP server, and physical port assignments. This MAC Filtering can be used as a coarse version of AAA Override, and normally takes precedence over any AAA (RADIUS or other) Override.

However, when Allow AAA Override is enabled, the RADIUS (or other AAA) server can alternatively be configured to return QoS and ACL on a per-MAC Address basis. Allow AAA Override gives the AAA Override precedence over the MAC Filtering parameters set in the Cisco Wireless LAN Controller; if there are no AAA Overrides available for a given MAC Address, the operating system uses the MAC Filtering parameters already in the Cisco Wireless LAN Controller. This AAA (RADIUS or other) Override can be used as a finer version of AAA Override, but only takes precedence over MAC Filtering when Allow AAA Override is enabled.

Note that in all cases, the Override parameters (Operator-Defined Interface and QoS, for example) must already be defined in the Cisco Wireless LAN Controller configuration.

In all cases, the operating system will use QoS and ACL provided by the AAA server or MAC Filtering regardless of the Layer 2 and/or Layer 3 authentication used.

Also note that the operating system will only move clients from the default Cisco WLAN Solution wireless LAN VLAN to a different VLAN when configured for MAC filtering, 802.1X, and/or WPA Layer 2 authentication.

To configure the Cisco WLAN Solution wireless LANs, refer to the "Configuring Wireless LANs" section on page 6-2.

Enhanced Integration with Cisco Secure ACS

The identity-based networking feature uses authentication, authorization, and accounting (AAA) override. When the following vendor-specific attributes are present in the RADIUS access accept message, the values override those present in the wireless LAN profile:

- QoS level
- 802.1p value
- VLAN interface name
- Access control list (ACL) name

In this release, support is being added for the AAA server to return the VLAN number or name using the standard "RADIUS assigned VLAN name/number" feature defined in IETF RFC 2868 (RADIUS Attributes for Tunnel Protocol Support). To assign a wireless client to a particular VLAN, the AAA server sends the following attributes to the controller in the access accept message:

- IETF 64 (Tunnel Type): VLAN
- IETF 65 (Tunnel Medium Type): 802
- IETF 81 (Tunnel Private Group ID): VLAN # or VLAN Name String

This enables Cisco Secure ACS to communicate a VLAN change that may be a result of a posture analysis. Benefits of this new feature include:

- Integration with Cisco Secure ACS reduces installation and setup time
- Cisco Secure ACS operates smoothly across both wired and wireless networks

This feature supports 2000, 4100, and 4400 series controllers and 1000, 1130, 1200 and 1500 series lightweight access points.

File Transfers

The Cisco Wireless LAN Solution operator can upload and download operating system code, configuration, and certificate files to and from a Cisco Wireless LAN Controller using CLI commands, Web User Interface commands, or Cisco WCS.

- To use CLI commands, refer to the "Transferring Files to and from a Controller" section on page 8-2.
- To use Cisco WCS to upgrade software, refer to the *Cisco Wireless Control System Configuration Guide*. Click this URL to browse to this document:

  http://www.cisco.com/en/US/products/ps6305/products_installation_and_configuration_guides_list.html

Power over Ethernet

Lightweight access points can receive power via their Ethernet cables from 802.3af-compatible Power over Ethernet (PoE) devices, which can reduce the cost of discrete power supplies, additional wiring, conduits, outlets, and installer time. PoE also frees installers from having to mount Cisco 1000 series lightweight access points or other powered equipment near AC outlets, providing greater flexibility in positioning Cisco 1000 series lightweight access points for maximum coverage.

When you are using PoE, the installer runs a single CAT-5 cable from each lightweight access point to PoE-equipped network elements, such as a PoE power hub or a Cisco WLAN Solution Single-Line PoE Injector. When the PoE equipment determines that the lightweight access point is PoE-enabled, it sends 48 VDC over the unused pairs in the Ethernet cable to power the lightweight access point.

The PoE cable length is limited by the 100BASE-T or 10BASE-T specification to 100 m or 200 m, respectively.

Lightweight access points can receive power from an 802.3af-compliant device or from the external power supply.

Pico Cell Functionality

A Pico Cell is a small area of wireless provisioning provided by antenna, which allows for a dense high-bandwidth deployment for installations such as stock exchanges. Pico Cell wireless configurations require a specific supplicant to function correctly with Pico Cell environments. Off-the-shelf laptop supplicants are not supported.

Note Do not attempt to configure Pico Cell functionality within your wireless LAN without consulting your sales team. Non-standard installation is not supported.

Note Do not change the configuration database setting unless you are committing to a Pico Cell installation or without the advice of Cisco technical support.

Pico Cell functionality includes optimization of the operating system (operating system) to support this functionality as follows:

- The Cisco WCS Pico Cell Mode parameter reconfigures operating system parameters, allowing operating system to function efficiently in pico cell deployments. Note that when the operator is deploying a pico cell network the operating system must also have more memory allocated (512 to 2048 MB) using the **config database size 2048** CLI command.
- Client mobility between multiple mobility domains when such exist.
- Addition of a WPA2 VFF extension to eliminate the need to re-key after every association. This allows the re-use of existing PTK and GTK.
- With WPA2 PMK caching and VFF, the PMK cache is transferred as part of context transfer prior to the authentication phase. This allows expedited handoffs to work for both intra- and inter-Cisco Wireless LAN Controller roaming events.
- A beacon/probe response that allows a Cisco 1000 Series lightweight access point to indicate which Cisco Wireless LAN Controller it is attached to so that reauthorization events only occur when needed, minimizing inter-Cisco Wireless LAN Controller handoffs and thus reducing CPU usage.

- Allows changes to Cisco 1000 series lightweight access point sensitivity for pico cells.
- Allows control of Cisco 1000 series lightweight access point fallback behavior to optimize pico cell use.
- Supports heat maps for directional antennas.
- Allows specific control over blacklisting events
- Allows configuring and viewing basic LWAPP configuration using the Cisco 1000 series lightweight access point CLI.

Intrusion Detection Service (IDS)

Intrusion Detection Service includes the following:

- Sensing Clients probing for “ANY” SSID
- Sensing if Cisco 1000 series lightweight access points are being contained
- Notification of MiM Attacks, NetStumbler, Wellenreiter
- Management Frame Detection and RF Jamming Detection
- Spoofed Deauthentication Detection (AirJack, for example)
- Broadcast Deauthorization Detection
- Null Probe Response Detection
- Fake AP Detection
- Detection of Weak WEP Encryption
- MAC Spoofing Detection
- AP Impersonation Detection
- Honeypot AP Detection
- Valid Station Protection
- Misconfigured AP Protection
- Rogue Access Point Detection
- AD-HOC Detection and Protection
- Wireless Bridge Detection
- Asleep Detection / Protection

Wireless LAN Controller Platforms

Cisco controllers are enterprise-class high-performance wireless switching platforms that support 802.11a and 802.11b/802.11g protocols. They operate under control of the operating system, which includes the Radio Resource Management (RRM), creating a Cisco WLAN Solution that can automatically adjust to real-time changes in the 802.11 RF environment. The controllers are built around high-performance network and security hardware, resulting in highly-reliable 802.11 enterprise networks with unparalleled security.

Cisco 2000 Series Wireless LAN Controllers

The Cisco 2000 Series Wireless LAN Controller is part of the Cisco Wireless LAN Solution. Each 2000 series controller controls up to six Cisco 1000 series lightweight access points, making it ideal for smaller enterprises and low-density applications.

The Cisco 2000 Series Wireless LAN Controller is a slim 9.5 x 6.0 x 1.6 in. (241 x 152 x 41 mm) chassis that can be desktop or shelf mounted. The Cisco 2000 Series Wireless LAN Controller front panel has one POWER LED and four sets of Ethernet LAN Port status LEDs, which indicate 10 MHz or 100 MHz connections and transmit/receive Activity for the four corresponding back-panel Ethernet LAN connectors. The Cisco 2000 Series Wireless LAN Controller is shipped with four rubber desktop/shelf mounting feet.

Cisco 4100 Series Wireless LAN Controllers

The Cisco 4100 Series Wireless LAN Controllers are part of the Cisco Wireless LAN Solution. Each Cisco 4100 Series Wireless LAN Controller controls up to 36 Cisco 1000 series lightweight access points, making it ideal for medium-sized enterprises and medium-density applications.

Figure 1-4 shows the Cisco 4100 Series Wireless LAN Controller, which has two redundant front-panel SX/LC jacks. Note that the 1000BASE-SX circuits provides a 100/1000 Mbps wired connection to a network through an 850nM (SX) fiber-optic link using an LC physical connector.

Figure 1-4 4100 Series Controller

The Cisco 4100 Series Wireless LAN Controller can be factory-ordered with a VPN/Enhanced Security Module (Crypto Card) to support VPN, IPSec and other processor-intensive tasks, and contains two (Cisco 4100 Series Wireless LAN Controller) 1000BASE-SX network connectors that allow the Cisco 4100 Series Wireless LAN Controller to communicate with the network at Gigabit Ethernet speeds. The 1000BASE-SX network connectors provides 100/1000 Mbps wired connections to a network through 850nM (SX) fiber-optic links using LC physical connectors.

The two redundant Gigabit Ethernet connections on the Cisco 4100 Series Wireless LAN Controller allow the Cisco 4100 Series Wireless LAN Controller to bypass single network failures.

Cisco 4400 Series Wireless LAN Controllers

Cisco 4400 Series Wireless LAN Controllers are part of the Cisco Wireless LAN Solution. Each Cisco 4400 Series Wireless LAN Controller controls up to 100 Cisco 1000 series lightweight access points, making it ideal for large-sized enterprises and large-density applications.

The 4402 Cisco 4400 Series Wireless LAN Controller has one set of two redundant front-panel SX/LC/T SFP modules (SFP transceiver, or Small Form-factor Plug-in), and the 4404 Cisco 4400 Series Wireless LAN Controller has two sets of two redundant front-panel SX/LC/T SFP modules:

- 1000BASE-SX SFP modules provide a 1000 Mbps wired connection to a network through an 850nM (SX) fiber-optic link using an LC physical connector.
- 1000BASE-LX SFP modules provide a 1000 Mbps wired connection to a network through a 1300nM (LX/LH) fiber-optic link using an LC physical connector.
- 1000BASE-T SFP modules provide a 1000 Mbps wired connection to a network through a copper link using an RJ-45 physical connector.

The one or two sets of redundant Gigabit Ethernet connections on the Cisco 4400 Series Wireless LAN Controller allow the Cisco 4400 Series Wireless LAN Controller to bypass single network failures.

The Cisco 4400 Series Wireless LAN Controller can be equipped with one or two Cisco 4400 series power supplies. When the Cisco Wireless LAN Controller is equipped with two Cisco 4400 series power supplies, the power supplies are redundant and either power supply can continue to power the Cisco 4400 Series Wireless LAN Controller if the other power supply fails.

One Cisco 4400 series power supply is included standard with the Cisco Wireless LAN Controller, and is installed in Slot 1 at the factory. For redundancy, a second Cisco 4400 series power supply can be ordered from the factory and may be installed in Slot 2. The same power supply also fits in Slot 1 and can be used to replace a failed power supply in the field.

Cisco 2000 Series Wireless LAN Controller Model Numbers

Cisco 2000 Series Wireless LAN Controller model number is as follows:

- AIR-WLC2006-K9 — The Cisco 2000 Series Wireless LAN Controller communicates with up to six Cisco 1000 series lightweight access points.

Note Cisco 2000 Series Wireless LAN Controllers come from the factory with tabletop mounting feet.

Cisco 4100 Series Wireless LAN Controller Model Numbers

Cisco 4100 Series Wireless LAN Controller model numbers are as follows:

- AIR-WLC4112-K9 — The Cisco 4100 Series Wireless LAN Controller uses two redundant Gigabit Ethernet connections to bypass single network failures, and communicates with up to 12 Cisco 1000 series lightweight access points. The 1000BASE-SX Network Adapters provide 100/1000 Mbps wired connections to a network through 850nM (SX) fiber-optic links using LC physical connectors.
- AIR-WLC4124-K9 — The Cisco 4100 Series Wireless LAN Controller uses two redundant Gigabit Ethernet connections to bypass single network failures, and communicates with up to 24 Cisco 1000 series lightweight access points.
- AIR-WLC4136-K9 — The Cisco 4100 Series Wireless LAN Controller uses two redundant Gigabit Ethernet connections to bypass single network failures, and communicates with up to 36 Cisco 1000 series lightweight access points.

Note Cisco 4100 Series Wireless LAN Controller models come from the factory with 19-inch EIA equipment rack flush-mount ears.

The following upgrade module is also available:

- AIR-VPN-4100 — VPN/Enhanced Security Module: Supports VPN, L2TP, IPSec and other processor-intensive security options. This is a field-installable option for all Cisco 4100 Series Wireless LAN Controllers.

Cisco 4400 Series Wireless LAN Controller Model Numbers

Cisco 4400 Series Wireless LAN Controller model numbers are as follows:

- AIR-WLC4402-12-K9 — The 4402 Cisco 4400 Series Wireless LAN Controller uses two redundant Gigabit Ethernet connections to bypass single network failures, and communicates with up to 12 Cisco 1000 series lightweight access points.
- AIR-WLC4402-25-K9 — The 4402 Cisco Wireless LAN Controller uses two redundant Gigabit Ethernet connections to bypass single network failures, and communicates with up to 25 Cisco 1000 series lightweight access points.
- AIR-WLC4402-50-K9 — The 4402 Cisco Wireless LAN Controller uses two redundant Gigabit Ethernet connections to bypass single network failures, and communicates with up to 50 Cisco 1000 series lightweight access points.
- AIR-WLC4404-100-K9 — The 4404 Cisco Wireless LAN Controller uses four redundant Gigabit Ethernet connections to bypass one or two single network failures, and communicates with up to 100 Cisco 1000 series lightweight access points.

Note Cisco 4400 Series Wireless LAN Controller models come from the factory with integral 19-inch EIA equipment rack flush-mount ears.

The 4402 Cisco 4400 Series Wireless LAN Controller uses one set of two redundant front-panel SX/LC/T SFP modules (SFP transceiver, or Small Form-factor Plug-in), and the 4404 Cisco 4400 Series Wireless LAN Controller uses two sets of two redundant front-panel SX/LC/T SFP modules:

- 1000BASE-SX SFP modules provide a 1000 Mbps wired connection to a network through an 850nM (SX) fiber-optic link using an LC physical connector.
- 1000BASE-LX SFP modules provide a 1000 Mbps wired connection to a network through a 1300nM (LX/LH) fiber-optic link using an LC physical connector.
- 1000BASE-T SFP modules provide a 1000 Mbps wired connection to a network through a copper link using an RJ-45 physical connector.

The following power supply module is also available:

- AIR-PWR-4400-AC — All Cisco 4400 series power supplies. One Cisco 4400 series power supply can power Cisco 4400 series power supplies can power Cisco 4400 series power supplies, the Cisco 4400 series power supplies are redundant.

Startup Wizard

When an Cisco Wireless LAN Controller is powered up with a new factory operating system software load or after being reset to factory defaults, the bootup script runs the Startup Wizard, which prompts the installer for initial configuration. The Startup Wizard:

- Ensures that the Cisco Wireless LAN Controller has a System Name, up to 32 characters.
- Adds an Administrative username and password, each up to 24 characters.
- Ensures that the Cisco Wireless LAN Controller can communicate with the CLI, Cisco WCS, or Web User interfaces (either directly or indirectly) through the service port by accepting a valid IP configuration protocol (none or DHCP), and if none, IP Address and netmask. If you do not want to use the Service port, enter 0.0.0.0 for the IP Address and netmask.
- Ensures that the Cisco Wireless LAN Controller can communicate with the network (802.11 Distribution System) through the management interface by collecting a valid static IP Address, netmask, default router IP address, VLAN identifier, and physical port assignment.
- Prompts for the IP address of the DHCP server used to supply IP addresses to clients, the Cisco Wireless LAN Controller Management Interface, and optionally to the Service Port Interface.
- Asks for the LWAPP Transport Mode, described in the "Layer 2 and Layer 3 LWAPP Operation" section on page 1-7.
- Collects the Virtual Gateway IP Address; any fictitious, unassigned IP address (such as 1.1.1.1) to be used by Layer 3 Security and Mobility managers.
- Allows you to enter the Mobility Group (RF Group) Name.
- Collects the wireless LAN 1 802.11 SSID, or Network Name.
- Asks you to define whether or not clients can use static IP addresses. Yes = more convenient, but lower security (session can be hijacked), clients can supply their own IP Address, better for devices that cannot use DHCP. No = less convenient, higher security, clients must DHCP for an IP Address, works well for Windows XP devices.
- If you want to configure a RADIUS server from the Startup Wizard, the RADIUS server IP address, communication port, and Secret.
- Collects the Country Code.

- Enables and/or disables the 802.11a, 802.11b and 802.11g Cisco 1000 series lightweight access point networks.
- Enables or disables Radio Resource Management (RRM).

To use the Startup Wizard, refer to the "Using the Configuration Wizard" section on page 4-2.

Cisco Wireless LAN Controller Memory

The Cisco Wireless LAN Controller contain two kinds of memory: volatile RAM, which holds the current, active Cisco Wireless LAN Controller configuration, and NVRAM (non-volatile RAM), which holds the reboot configuration. When you are configuring the operating system in a Cisco Wireless LAN Controller, you are modifying volatile RAM; you must save the configuration from the volatile RAM to the NVRAM to ensure that the Cisco Wireless LAN Controller reboots in the current configuration.

Knowing which memory you are modifying is important when you are:

- Using the Configuration Wizard
- Clearing the Controller Configuration
- Saving Configurations
- Resetting the Controller
- Logging Out of the CLI

Cisco Wireless LAN Controller Failover Protection

Each Cisco Wireless LAN Controller has a defined number of communication ports for Cisco 1000 series lightweight access points. This means that when multiple controllers with unused access point ports are deployed on the same network, if one controller fails, the dropped access points automatically poll for unused controller ports and associate with them.

During installation, Cisco recommends that you connect all lightweight access points to a dedicated controller, and configure each lightweight access point for final operation. This step configures each lightweight access point for a primary, secondary, and tertiary controller, and allows it to store the configured WLAN Solution Mobility Group information.

During failover recovery, the configured lightweight access points obtain an IP address from the local DHCP server (only in Layer 3 Operation), attempt to contact their primary, secondary, and tertiary controllers, and then attempt to contact the IP addresses of the other controllers in the Mobility group. This prevents the access points from spending time sending out blind polling messages, resulting in a faster recovery period.

In multiple-controller deployments, this means that if one controller fails, its dropped access points reboot and do the following under direction of the Radio Resource Management (RRM):

- Obtain an IP address from a local DHCP server (one on the local subnet).
- If the Cisco 1000 series lightweight access point has a primary, secondary, and tertiary controller assigned, it attempts to associate with that controller.
- If the access point has no primary, secondary, or tertiary controllers assigned or if its primary, secondary, or tertiary controllers are unavailable, it attempts to associate with a master controller on the same subnet.

- If the access point finds no master controller on the same subnet, it attempts to contact stored Mobility Group members by IP address.
- Should none of the Mobility Group members be available, and if the Cisco 1000 series lightweight access point has no Primary, Secondary, and Tertiary Cisco Wireless LAN Controllers assigned and there is no master Cisco Wireless LAN Controller active, it attempts to associate with the least-loaded Cisco Wireless LAN Controller on the same subnet to respond to its discovery messages with unused ports.

This means that when sufficient controllers are deployed, should one controller fail, active access point client sessions are momentarily dropped while the dropped access point associates with an unused port on another controller, allowing the client device to immediately reassociate and reauthenticate.

Cisco Wireless LAN Controller Automatic Time Setting

Each controller can have its time manually set or can be configured to obtain the current time from one or more Network Time Protocol (NTP) servers. Each NTP server IP address is added to the controller database. Each controller searches for an NTP server and obtains the current time upon reboot and at each user-defined polling interval (daily to weekly).

Cisco Wireless LAN Controller Time Zones

Each Cisco Wireless LAN Controller can have its time zone manually set or can be configured to obtain the current time from one or more Network Time Protocol (NTP) servers. Each NTP server IP address is added to the Cisco Wireless LAN Controller database. Each Cisco Wireless LAN Controller can search for an NTP server and obtain the current time zone upon reboot and at each user-defined (daily to weekly) polling interval.

Network Connections to Cisco Wireless LAN Controllers

Regardless of operating mode, all Cisco Wireless LAN Controllers use the network as an 802.11 Distribution System. Regardless of the Ethernet port type or speed, each controller monitors and communicates with its related controllers across the network. The following sections give details of these network connections:

- Cisco 2000 Series Wireless LAN Controllers, page 1-16
- Cisco 4100 Series Wireless LAN Controllers, page 1-16
- Cisco 4400 Series Wireless LAN Controllers, page 1-17

Note Chapter 3 provides information on configuring the controller's ports and assigning interfaces to them.

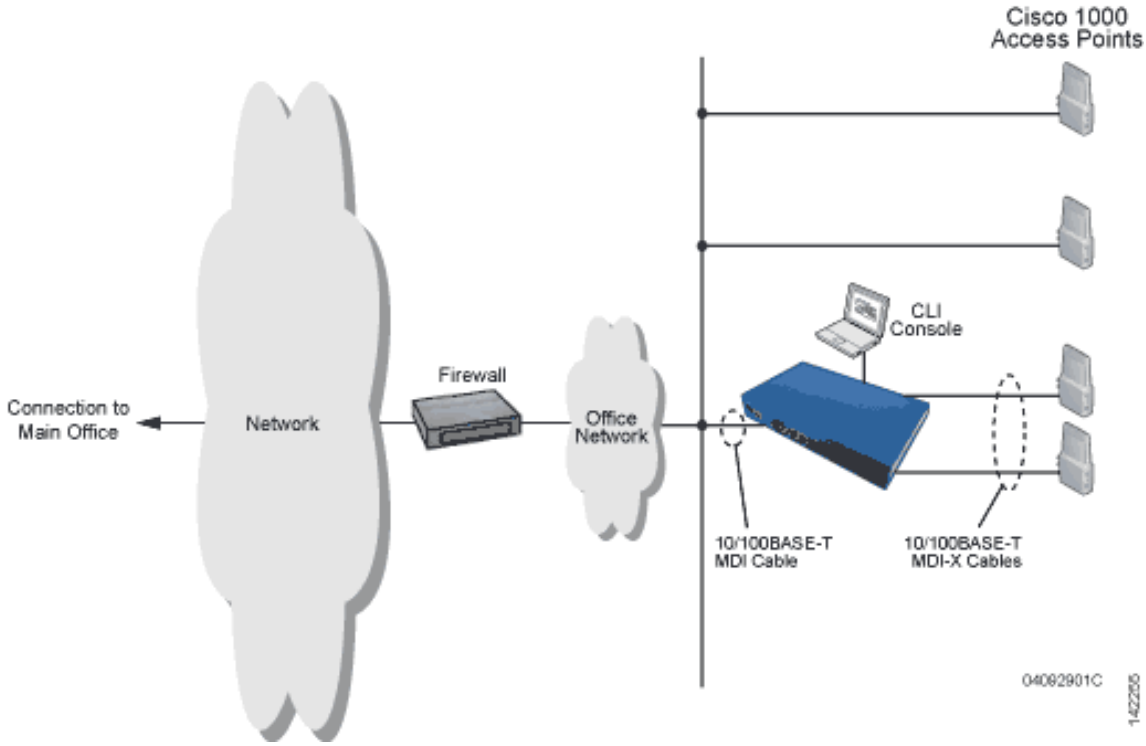
Cisco 2000 Series Wireless LAN Controllers

Cisco 2000 Series Wireless LAN Controllers can communicate with the network through any one of its physical data ports, as the logical management interface can be assigned to one of the ports. The physical port description follows:

- Up to four 10/100BASE-T cables can plug into the four back-panel data ports on the Cisco 2000 Series Wireless LAN Controller chassis.

Figure 1-5 shows connections to the 2000 series controller.

Figure 1-5 Physical Network Connections to the 2000 Series Controller



Cisco 4100 Series Wireless LAN Controllers

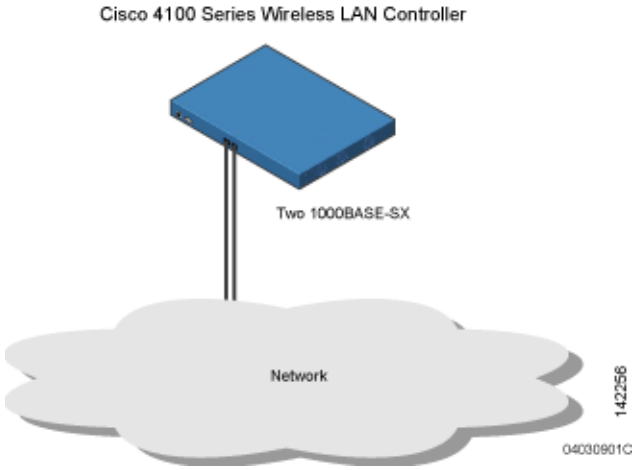
Cisco 4100 Series Wireless LAN Controllers can communicate with the network through one or two physical data ports, as the logical management interface can be assigned to one or both ports. The physical port description follows:

- Two Gigabit Ethernet 1000BASE-SX fiber-optic cables can plug into the LC connectors on the front of the Cisco 4100 Series Wireless LAN Controller, and they must be connected to the same subnet. Note that the two Gigabit Ethernet ports are redundant--the first port that becomes active is the master, and the second port becomes the backup port. If the first connection fails, the standby connection becomes the master, and the failed connection becomes the backup port.

Note The 1000BASE-SX circuits provide 100/1000 Mbps wired connections to the network through 850nM (SX) fiber-optic links using LC physical connectors.

Figure 1-6 shows connections to the 4100 series controller.

Figure 1-6 Physical Network Connections to the 4100 Series Controller



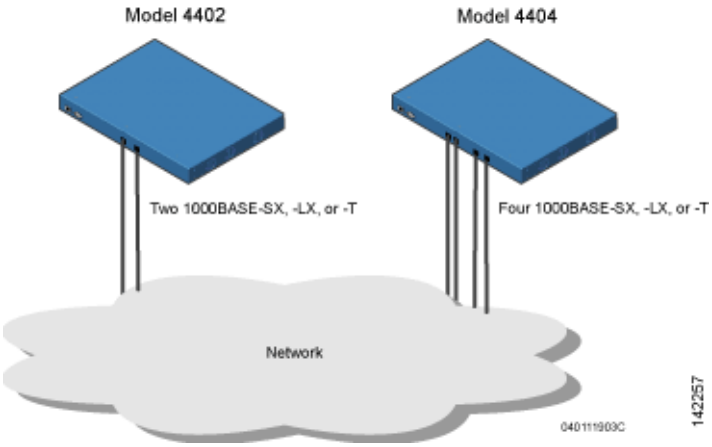
Cisco 4400 Series Wireless LAN Controllers

Cisco 4400 Series Wireless LAN Controllers can communicate with the network through one or two pairs of physical data ports, and the logical management interface can be assigned to the ports. The physical port descriptions follows:

- For the 4402 Cisco Wireless LAN Controller, up to two of the following connections are supported in any combination:
  - 1000BASE-T (Gigabit Ethernet, front panel, RJ-45 physical port, UTP cable).
  - 1000BASE-SX (Gigabit Ethernet, front panel, LC physical port, multi-mode 850nM (SX) fiber-optic links using LC physical connectors).
  - 1000BASE-LX (Gigabit Ethernet, front panel, LC physical port, multi-mode 1300nM (LX/LH) fiber-optic links using LC physical connectors).
- For the 4404 Cisco Wireless LAN Controller, up to four of the following connections are supported in any combination:
  - 1000BASE-T (Gigabit Ethernet, front panel, RJ-45 physical port, UTP cable).
  - 1000BASE-SX (Gigabit Ethernet, front panel, LC physical port, multi-mode 850nM (SX) fiber-optic links using LC physical connectors).
  - 1000BASE-LX (Gigabit Ethernet, front panel, LX physical port, multi-mode 1300nM (LX/LH) fiber-optic links using LC physical connectors).

Figure 1-7 shows connections to the 4400 series controller.

Figure 1-7 Physical Network Connections to 4402 and 4404 Series Controllers



VPN and Enhanced Security Modules for 4100 Series Controllers

All 4100 series controllers can be equipped with an optional module that slides into the rear panel of the controller. The 4100 Series VPN/Enhanced Security Module adds significant hardware encryption acceleration to the controller, which enables the following through the management interface:

- Provide a built-in VPN server for mission-critical traffic.
- Sustain up to 1 Gbps throughput with Layer 2 and Layer 3 encryption enabled.
- Support high-speed, processor-intensive encryption, such as L2TP, IPSec and 3DES.

Rogue Access Points

Because they are inexpensive and readily available, employees sometimes plug unauthorized rogue access points into existing LANs and build ad hoc wireless networks without IT department knowledge or consent.

These rogue access points can be a serious breach of network security because they can be plugged into a network port behind the corporate firewall. Because employees generally do not enable any security settings on the rogue access point, it is easy for unauthorized users to use the access point to intercept network traffic and hijack client sessions. Even more alarming, wireless users and war chalkers frequently publish unsecure access point locations, increasing the odds of having the enterprise security breached.

Rather than using a person with a scanner to manually detect rogue access point, the Cisco Wireless LAN Solution automatically collects information on rogue access point detected by its managed access points, by MAC and IP Address, and allows the system operator to locate, tag and monitor them. The operating system can also be used to discourage rogue access point clients by sending them deauthenticate and disassociate messages from one to four Cisco 1000 series lightweight access points. Finally, the operating system can be used to automatically discourage all clients attempting to authenticate with all rogue access point on the enterprise subnet. Because this real-time detection is automated, it saves labor costs used for detecting and monitoring rogue access point while vastly improving LAN security. Note that peer-to-peer, or ad-hoc, clients can also be considered rogue access points.

Rogue Access Point Location, Tagging, and Containment

This built-in detection, tagging, monitoring, and containment capability allows system administrators to take required actions:

- Locate rogue access point as described in the *Cisco Wireless Control System Configuration Guide*.
- Receive new rogue access point notifications, eliminating hallway scans.
- Monitor unknown rogue access point until they are eliminated or acknowledged.
- Determine the closest authorized access point, making directed scans faster and more effective.
- Contain rogue access points by sending their clients deauthenticate and disassociate messages from one to four Cisco 1000 series lightweight access points. This containment can be done for individual rogue access points by MAC address, or can be mandated for all rogue access points connected to the enterprise subnet.
- Tag rogue access points:
  - Acknowledge rogue access point when they are outside of the LAN and do not compromise the LAN or wireless LAN security.
  - Accept rogue access point when they do not compromise the LAN or wireless LAN security.
  - Tag rogue access point as unknown until they are eliminated or acknowledged.
  - Tag rogue access point as contained and discourage clients from associating with the rogue access point by having between one and four Cisco 1000 series lightweight access points transmit deauthenticate and disassociate messages to all rogue access point clients. This function contains all active channels on the same rogue access point.

Rogue Detector mode detects whether or not a rogue access point is on a trusted network. It does not provide RF service of any kind, but rather receives periodic rogue access point reports from the Cisco Wireless LAN Controller, and sniffs all ARP packets. If it finds a match between an ARP request and a MAC address it receives from the Cisco Wireless LAN Controller, it generates a rogue access point alert to the Cisco Wireless LAN Controller.

To facilitate automated rogue access point detection in a crowded RF space, Cisco 1000 series lightweight access points can be configured to operate in monitor mode, allowing monitoring without creating unnecessary interference.

Web User Interface and the CLI

This section describes the controller GUI and CLI.

Web User Interface

The Web User Interface is built into each Cisco Wireless LAN Controller. The Web User Interface allows up to five users to simultaneously browse into the built-in Cisco Wireless LAN Controller http or https (http + SSL) Web server, configure parameters, and monitor operational status for the Cisco Wireless LAN Controller and its associated Access Points.

Note Cisco recommends that you enable the https: and disable the http: interfaces to ensure more robust security for your Cisco WLAN Solution.

Because the Web User Interface works with one Cisco Wireless LAN Controller at a time, the Web User Interface is especially useful when you wish to configure or monitor a single Cisco Wireless LAN Controller and its associated Cisco 1000 series lightweight access points.

Refer to the "Using the Web-Browser Interface" section on page 2-2 for more information on the Web User Interface.

Command Line Interface

The Cisco Wireless LAN Solution command line interface (CLI) is built into each Cisco Wireless LAN Controller. The CLI allows operators to use a VT-100 emulator to locally or remotely configure, monitor and control individual Cisco Wireless LAN Controllers, and to access extensive debugging capabilities.

Because the CLI works with one Cisco Wireless LAN Controller at a time, the command line interface is especially useful when you wish to configure or monitor a single Cisco Wireless LAN Controller.

The Cisco Wireless LAN Controller and its associated Cisco 1000 series lightweight access points can be configured and monitored using the command line interface (CLI), which consists of a simple text-based, tree-structured interface that allows up to five users with Telnet-capable terminal emulators to simultaneously configure and monitor all aspects of the Cisco Wireless LAN Controller and associated Cisco 1000 series lightweight access points.

Refer to "Using the CLI" section on page 2-5 and the *Cisco Wireless LAN Solution CLI Reference* for more information.

CHAPTER 2

Using the Web-Browser and CLI Interfaces

This chapter describes the web-browser and CLI interfaces that you use to configure the controllers. It contains these sections:

Using the Web-Browser Interface

The web-browser interface (hereafter called the GUI) allows up to five users to browse simultaneously into the controller http or https (http + SSL) management pages to configure parameters and monitor operational status for the controller and its associated access points.

Guidelines for Using the GUI

Keep these guidelines in mind when using the GUI:

- The GUI must be used on a PC running Windows XP SP1 or higher or Windows 2000 SP4 or higher.
- The GUI is fully compatible with Microsoft Internet Explorer version 6.0 SP1 or higher.

Note Opera, Mozilla, and Netscape are not supported.

- You can use either the service port interface or the management interface to open the GUI. Cisco recommends that you use the service-port interface. Refer to the Configuring the Service Port section on page x for instructions on configuring the service port interface.
- You might need to disable your browser's pop-up blocker to view the online help.

Opening the GUI

To open the GUI, enter the controller IP address in the browser's address line. For an unsecure connection enter **http://***ip-address*. For a secure connection, enter **https://***ip-address*. See the "Configuring the GUI for HTTPS" section on page 2-2 for instructions on setting up HTTPS.

Enabling Web and Secure Web Modes

Use these commands to enable or disable the distribution system port as a web port or as a secure web port:

- **config network webmode** {**enable** | **disable**}
- **config network secureweb** {**enable** | **disable**}

Web and secure web modes are enabled by default.

Configuring the GUI for HTTPS

You can protect communication with the GUI by enabling HTTPS. HTTPS protects HTTP browser sessions by using the Secure Socket Layer (SSL) protocol. When you enable HTTPS, the controller generates its own local Web Administration SSL certificate and automatically applies it to the GUI.

You can also load an externally generated certificate. Follow the instructions in the "Loading an Externally Generated HTTPS Certificate" section on page 2-3 for instructions on loading an externally generated certificate.

Using the CLI, follow these steps to enable HTTPS:

Step 1 Enter **show certificate summary** to verify that the controller has generated a certificate:

```
>show certificate summary
Web Administration Certificate................. Locally Generated
Web Authentication Certificate................. Locally Generated
Certificate compatibility mode:................ off
```

Step 2 (Optional) If you need to generate a new certificate, enter this command:

```
>config certificate generate webadmin
```

After a few seconds the controller verifies that the certificate is generated:

```
Web Administration certificate has been generated
```

Step 3 Enter this command to enable HTTPS:

```
>config network secureweb enable
```

Step 4 Save the SSL certificate, key, and secure web password to NVRAM (non-volatile RAM) so your changes are retained across reboots:

```
>save config
Are you sure you want to save? (y/n) y
Configuration Saved!
```

Step 5 Reboot the controller:

```
>reset system
Are you sure you would like to reset the system? (y/n) y
System will now restart!
```

The controller reboots.

Loading an Externally Generated HTTPS Certificate

You use a TFTP server to load the certificate. Follow these guidelines for using TFTP:

- If you load the certificate through the service port, the TFTP server must be on the same subnet as the controller because the service port is not routable. However, if you load the certificate through the distribution system (DS) network port, the TFTP server can be on any subnet.
- The TFTP server cannot run on the same computer as the Cisco Wireless Control System (WCS) because WCS and the TFTP server use the same communication port.

Note Every HTTPS certificate contains an embedded RSA Key. The length of the RSA key can vary from 512 bits, which is relatively insecure, through thousands of bits, which is very secure. When you obtain a new certificate from a Certificate Authority, make sure the RSA key embedded in the certificate is at least 768 bits long.

Follow these steps to load an externally generated HTTPS certificate:

Step 1 Use a password to encrypt the HTTPS certificate in a .PEM-encoded file. The PEM-encoded file is called a Web Administration Certificate file (*webadmincert_name*.pem).

Step 2 Move the *webadmincert_name*.pem file to the default directory on your TFTP server.

Step 3 In the CLI, enter **transfer download start** and answer **n** to the prompt to view the current download settings:

```
>transfer download start
Mode..................................... TFTP
Data Type................................ Admin Cert
TFTP Server IP........................... xxx.xxx.xxx.xxx
TFTP Path................................ <directory path>
TFTP Filename.............................
Are you sure you want to start? (y/n) n
Transfer Canceled
```

Step 4 Use these commands to change the download settings:

```
>transfer download mode tftp
>transfer download datatype webauthcert
>transfer download serverip TFTP server IP address
>transfer download path absolute TFTP server path to the update file
>transfer download filename webadmincert_name.pem
```

Step 5 Enter the password for the .PEM file so the operating system can decrypt the Web Administration SSL key and certificate:

```
>transfer download certpassword private_key_password
>Setting password to private_key_password
```

Step 6 Enter **transfer download start** to view the updated settings, and answer **y** to the prompt to confirm the current download settings and start the certificate and key download:

```
>transfer download start
Mode..................................... TFTP
Data Type................................ Site Cert
TFTP Server IP........................... xxx.xxx.xxx.xxx
TFTP Path................................ directory path
TFTP Filename............................ webadmincert_name
Are you sure you want to start? (y/n) y
TFTP Webadmin cert transfer starting.
Certificate installed.
Please restart the switch (reset system) to use the new certificate.
```

Step 7 Enter this command to enable HTTPS:

```
>config network secureweb enable
```

Step 8 Save the SSL certificate, key, and secure web password to NVRAM (non-volatile RAM) so your changes are retained across reboots:

```
>save config
Are you sure you want to save? (y/n) y
Configuration Saved!
```

Step 9 Reboot the controller:

```
>reset system
Are you sure you would like to reset the system? (y/n) y
System will now restart!
```

The controller reboots.

Disabling the GUI

To prevent all use of the GUI, select the **Disable Web-Based Management** check box on the Services: HTTP-Web Server page and click **Apply**.

To re-enable the GUI, enter this command on the CLI:

```
>ip http server
```

Using Online Help

Click the help icon at the top of any page in the GUI to display online help. You might have to disable the browser pop-up blocker to view online help.

Using the CLI

The CLI allows you to use a VT-100 emulator to locally or remotely configure, monitor, and control a WLAN controller and its associated lightweight access points. The CLI is a simple text-based, tree-structured interface that allows up to five users with Telnet-capable terminal emulators to access the controller.

Logging into the CLI

You access the CLI using either of two methods:

- A direct ASCII serial connection to the controller console port
- A remote console session over Ethernet through the pre-configured Service Port or through Distribution System Ports

Before you log into the CLI, configure your connectivity and environment variables based on the type of connection you use.

Using a Local Serial Connection

You need these items to connect to the serial port:

- A computer that has a DB-9 serial port and is running a terminal emulation program
- A DB-9 male-to-female null-modem serial cable

Follow these steps to log into the CLI through the serial port.

Step 1 Connect your computer to the controller using the DB-9 null-modem serial cable.

Step 2 Open a terminal emulator session using these settings:

- 9600 baud
- 8 data bits
- 1 stop bit
- no parity
- no hardware flow control

Step 3 At the prompt, log into the CLI. The default username is *admin*, and the default password is *admin*.

Note The controller serial port is set for a 9600 baud rate and a short timeout. If you would like to change either of these values, enter **config serial baudrate** *baudrate* and **config serial timeout** *timeout* to make your changes. If you enter **config serial timeout 0**, serial sessions never time out.

Using a Remote Ethernet Connection

You need these items to connect to a controller remotely:

- A computer with access to the controller over the Ethernet network
- The IP Address of the controller
- A terminal emulation program or a DOS shell for the Telnet session

Note By default, controllers block Telnet sessions. You must use a local connection to the serial port to enable Telnet sessions.

Follow these steps to log into the CLI through the serial port:

Step 1 Verify that your terminal emulator or DOS shell interface is configured with these parameters:

- Ethernet address
- Port 23

Step 2 Use the controller IP address to Telnet to the CLI.

Step 3 At the prompt, log into the CLI. The default username is *admin* and the default password is *admin*.

Logging Out of the CLI

When you finish using the CLI, navigate to the root level and enter **logout**. The system prompts you to save any changes you made to the volatile RAM.

Navigating the CLI

The is organized around five levels:

Root Level

Level 2

Level 3

Level 4

Level 5

When you log into the CLI, you are at the root level. From the root level, you can enter any full command without first navigating to the correct command level. Table 2-1 lists commands you use to navigate the CLI and to perform common tasks.

Table 2-1 Commands for CLI Navigation and Common Tasks

Command	Action
help	At the root level, view systemwide navigation commands
?	View commands available at the current level
command **?**	View parameters for a specific command
exit	Move down one level
Ctrl-Z	Return from any level to the root level
save config	At the root level, save configuration changes from active working RAM to non-volatile RAM (NVRAM) so they are retained after reboot
reset system	At the root level, reset the controller without logging out

Enabling Wireless Connections to the Web-Browser and CLI Interfaces

You can monitor and configure controllers using a wireless client. This feature is supported for all management tasks except uploads from and downloads to the controller.

Before you can open the GUI or the CLI from a wireless client device you must configure the controller to allow the connection. Follow these steps to enable wireless connections to the GUI or CLI:

Step 1 Log into the CLI.

Step 2 Enter **config network mgmt-via-wireless enable**

Step 3 Use a wireless client to associate to a lightweight access point connected to the controller.

Step 4 On the wireless client, open a Telnet session to the controller, or browse to the controller GUI.

Tip To use the controller GUI to enable wireless connections, browse to the Management Via Wireless page and select the **Enable Controller Management to be accessible from Wireless Clients** check box.

CHAPTER 3

Configuring Ports and Interfaces

This chapter describes the controller's physical ports and interfaces and provides instructions for configuring them. It contains these sections:

Overview of Ports and Interfaces

Three concepts are key to understanding how controllers connect to a wireless network: ports, interfaces, and WLANs.

Ports

A *port* is a physical entity that is used for connections on the controller platform. Controllers have two types of ports: distribution system ports and a service port. The following figures show the ports available on each controller.

Note The controller in a Cisco Integrated Services Router and the controllers on the Cisco WiSM do not have external physical ports. They connect to the network through ports on the router or switch, respectively.

Figure 3-1 Ports on the Cisco 2000 Series Wireless LAN Controllers

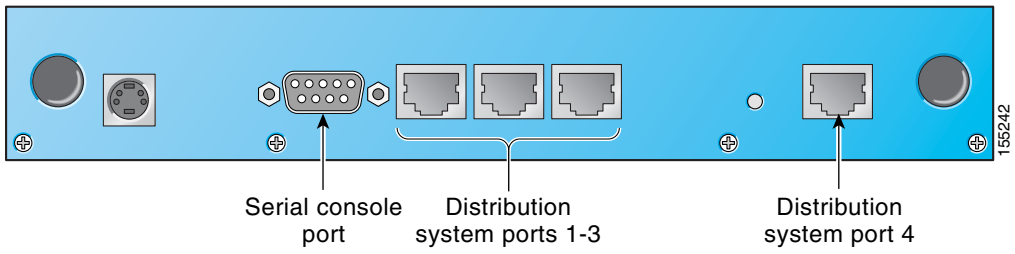


Figure 3-2 Ports on the Cisco 4100 Series Wireless LAN Controllers

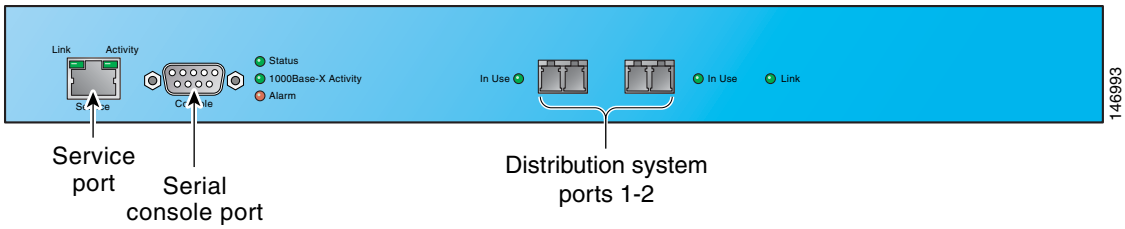
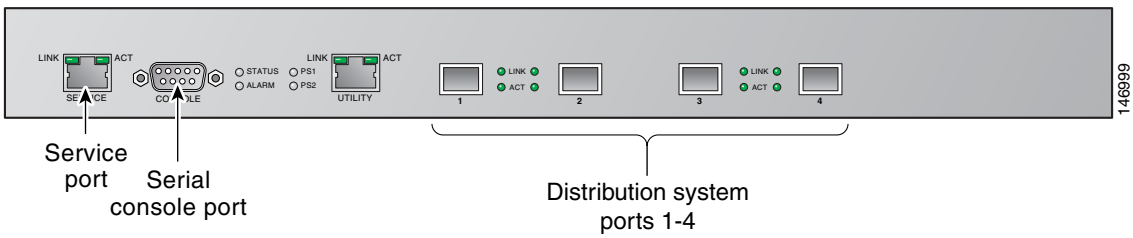


Figure 3-3 Ports on the Cisco 4400 Series Wireless LAN Controllers



Note Figure 3-3 shows a Cisco 4404 controller. The Cisco 4402 controller is similar but has only two distribution system ports.

Table 3-1 provides a list of ports per controller.

Table 3-1 Controller Ports

Controller	Service Ports	Distribution System Ethernet Ports	Serial Console Port
2000 series	None	4	1
4100 series	1	2	1
4402	1	2	1
4404	1	4	1
Cisco WiSM	2 (ports 9 and 10)	8 (ports 1-8)	2
Controller Network Module within the Cisco 28/37/38xx Series Integrated Services Routers	None	1	1

Distribution System Ports

A *distribution system port* connects the controller to a neighbor switch and serves as the data path between these two devices.

- Cisco 2000 series controllers have four 10/100 copper Ethernet distribution system ports through which the controller can support up to six access points.
- Cisco 4100 series controllers have two fiber gigabit Ethernet distribution system ports through which the controller can support up to 36 access points.
- Cisco 4402 controllers have two gigabit Ethernet distribution system ports, each of which is capable of managing up to 48 access points. However, Cisco recommends no more than 25 access points per port due to bandwidth constraints. The 4402-25 and 4402-50 models allow a total of 25 or 50 access points to join the controller.
- Cisco 4404 controllers have four gigabit Ethernet distribution system ports, each of which is capable of managing up to 48 access points. However, Cisco recommends no more than 25 access points per port due to bandwidth constraints. The 4404-25, 4404-50, and 4404-100 models allow a total of 25, 50, or 100 access points to join the controller.

Note The gigabit Ethernet ports on the 4402 and 4404 controllers accept these SX/LC/T small form-factor plug-in (SFP) modules:
- 1000BASE-SX SFP modules, which provide a 1000-Mbps wired connection to a network through an 850nM (SX) fiber-optic link using an LC physical connector
- 1000BASE-LX SFP modules, which provide a 1000-Mbps wired connection to a network through a 1300nM (LX/LH) fiber-optic link using an LC physical connector
- 1000BASE-T SFP modules, which provide a 1000-Mbps wired connection to a network through a copper link using an RJ-45 physical connector

- The Cisco WiSM has eight gigabit Ethernet distribution system ports, which are located on the Catalyst 6500 switch backplane. Through these ports, the controller can support up to 300 access points.
- The Controller Network Module within the Cisco 28/37/38xx Series Integrated Services Routers has one Fast Ethernet distribution system port, which is located on the router backplane. Through this port, the controller can support up to six access points.

Note Refer to the "Configuring a 4400 Series Controller to Support More Than 48 Access Points" section on page 3-30 if you want to configure your Cisco 4400 series controller to support more than 48 access points.

Each distribution system port is, by default, an 802.1Q VLAN trunk port. The VLAN trunking characteristics of the port are not configurable.

Note Some controllers support link aggregation (LAG), which bundles all of the controller's distribution system ports into a single 802.3ad port channel. Cisco 4400 series controllers support LAG in software release 3.2 and higher, and LAG is enabled automatically on the Cisco WiSM controllers. Refer to the "Enabling Link Aggregation" section on page 3-27 for more information.

Service Port

Cisco 4100 and 4400 series controllers also have a 10/100 copper Ethernet service port. The *service port* is controlled by the service-port interface and is reserved for out-of-band management of the controller and system recovery and maintenance in the event of a network failure. It is also the only port that is active when the controller is in boot mode. The service port is not capable of carrying 802.1Q tags, so it must be connected to an access port on the neighbor switch. Use of the service port is optional.

Note The Cisco WiSM's 4404 controllers use the service port for internal protocol communication between the controllers and the Supervisor 720.

Note The Cisco 2000 series controller and the controller in the Cisco Integrated Services Router do not have a service port.

Note The service port is not auto-sensing. You must use the correct straight-through or crossover Ethernet cable to communicate with the service port.

Interfaces

An *interface* is a logical entity on the controller. An interface has multiple parameters associated with it, including an IP address, default-gateway (for the IP subnet), primary physical port, secondary physical port, VLAN identifier, and DHCP server.

These five types of interfaces are available on the controller. Four of these are static and are configured at setup time:

- Management interface (Static and configured at setup time; mandatory)
- AP-manager interface (When using Layer 3 LWAPP, static and configured at setup time; mandatory)
- Virtual interface (Static and configured at setup time; mandatory)
- Service-port interface (Static and configured at setup time; optional)
- Dynamic interface (User-defined)

Each interface is mapped to at least one primary port, and some interfaces (management and dynamic) can be mapped to an optional secondary (or backup) port. If the primary port for an interface fails, the interface automatically moves to the backup port. In addition, multiple interfaces can be mapped to a single controller port.

Note Refer to the "Enabling Link Aggregation" section on page 3-27 if you want to configure the controller to dynamically map the interfaces to a single port channel rather than having to configure primary and secondary ports for each interface.

Management Interface

The *management interface* is the default interface for in-band management of the controller and connectivity to enterprise services such as AAA servers. The management interface has the only consistently "pingable" in-band interface IP address on the controller. You can access the controller's GUI by entering the controller's management interface IP address in Internet Explorer's Address field.

The management interface is also used for Layer 2 communications between the controller and Cisco 1000 series lightweight access points. It must be assigned to distribution system port 1 but can also be mapped to a backup port and can be assigned to WLANs if desired. It may be on the same VLAN or IP subnet as the AP-manager interface. However, the management interface can also communicate through the other distribution system ports as follows:

- Sends messages through the Layer 2 network to autodiscover and communicate with other controllers through all distribution system ports.
- Listens across the Layer 2 network for Cisco 1000 series lightweight access point LWAPP polling messages to autodiscover, associate to, and communicate with as many Cisco 1000 series lightweight access points as possible.

When LWAPP communications are set to Layer 2 (same subnet) mode, the controller requires one management interface to control all inter-controller and all controller-to-access point communications, regardless of the number of ports. When LWAPP communications are set to Layer 3 (different subnet) mode, the controller requires one management interface to control all inter-controller communications and one AP-manager interface to control all controller-to-access point communications, regardless of the number of ports.

Note If the service port is in use, the management interface must be on a different subnet from the service-port interface.

AP-Manager Interface

A controller has one or more *AP-manager interfaces*, which are used for all Layer 3 communications between the controller and lightweight access points after the access points have joined the controller. The AP-manager IP address is used as the tunnel source for LWAPP packets from the controller to the access point and as the destination for LWAPP packets from the access point to the controller.

The static (or permanent) AP-manager interface must be assigned to distribution system port 1 and must have a unique IP address. It cannot be mapped to a backup port. It is usually configured on the same VLAN or IP subnet as the management interface, but this is not a requirement. The AP-manager interface can communicate through any distribution system port as follows:

- Sends Layer 3 messages through the network to autodiscover and communicate with other controllers.
- Listens across the network for Layer 3 lightweight access point LWAPP polling messages to autodiscover, associate to, and communicate with as many lightweight access points as possible.

Note Refer to the "Using Multiple AP-Manager Interfaces" section on page 3-31 for information on creating and using multiple AP-manager interfaces.

Note When LAG is disabled, you must assign an AP-manager interface to each port on the controller.

Virtual Interface

The *virtual interface* is used to support mobility management, Dynamic Host Configuration Protocol (DHCP) relay, and embedded Layer 3 security such as guest web authentication and VPN termination. It also maintains the DNS gateway host name used by Layer 3 security and mobility managers to verify the source of certificates when Layer 3 web authorization is enabled.

Specifically, the virtual interface plays these three primary roles:

- Acts as the DHCP server placeholder for wireless clients that obtain their IP address from a DHCP server.
- Serves as the redirect address for the Web Authentication Login window.

  Note See Chapter 5 for additional information on web authentication.

- Acts as part of the IPSec configuration when the controller is used to terminate IPSec tunnels between wireless clients and the controller.

The virtual interface IP address is used only in communications between the controller and wireless clients. It never appears as the source or destination address of a packet that goes out a distribution system port and onto the switched network. For the system to operate correctly, the virtual interface IP address must be set (it cannot be 0.0.0.0), and no other device on the network can have the same address as the virtual interface. Therefore, the virtual interface must be configured with an unassigned and

unused gateway IP address, such as 1.1.1.1. The virtual interface IP address is not pingable and should not exist in any routing table in your network. In addition, the virtual interface cannot be mapped to a backup port.

Note All controllers within a mobility group must be configured with the same virtual interface IP address. Otherwise, inter-controller roaming may appear to work, but the hand-off does not complete, and the client loses connectivity for a period of time.

Service-Port Interface

The *service-port interface* controls communications through and is statically mapped by the system to the service port. It must have an IP address on a different subnet from the management, AP-manager, and any dynamic interfaces, and it cannot be mapped to a backup port. This configuration enables you to manage the controller directly or through a dedicated operating system network, such as 10.1.2.x, which can ensure service access during network downtime.

The service port can obtain an IP address using DHCP, or it can be assigned a static IP address, but a default gateway cannot be assigned to the service-port interface. Static routes can be defined through the controller for remote network access to the service port.

Note Only Cisco 4100 and 4400 series controllers have a service-port interface.

Note You must configure an IP address on the service-port interface of both Cisco WiSM controllers. Otherwise, the neighbor switch is unable to check the status of each controller.

Dynamic Interface

Dynamic interfaces, also known as *VLAN interfaces*, are created by users and designed to be analogous to VLANs for wireless LAN clients. A controller can support up to 512 dynamic interfaces (VLANs). Each dynamic interface is individually configured and allows separate communication streams to exist on any or all of a controller's distribution system ports. Each dynamic interface controls VLAN and other communications between controllers and all other network devices, and each acts as a DHCP relay for wireless clients associated to WLANs mapped to the interface. You can assign dynamic interfaces to distribution system ports, WLANs, the Layer 2 management interface, and the Layer 3 AP-manager interface, and you can map the dynamic interface to a backup port.

You can configure zero, one, or multiple dynamic interfaces on a distribution system port. However, all dynamic interfaces must be on a different VLAN or IP subnet from all other interfaces configured on the port. If the port is untagged, all dynamic interfaces must be on a different IP subnet from any other interface configured on the port.

Note Tagged VLANs must be used for dynamic interfaces.

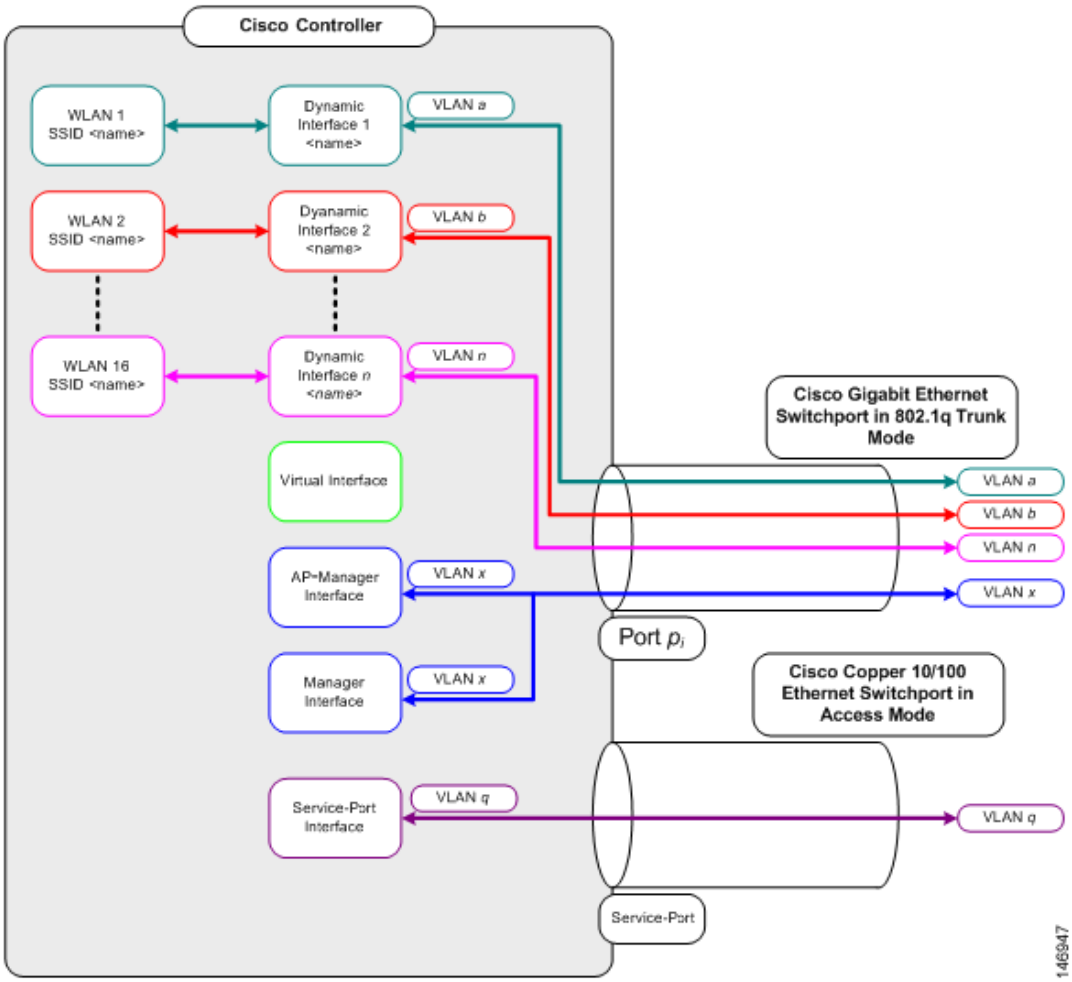
WLANs

A *WLAN* associates a service set identifier (SSID) to an interface. It is configured with security, quality of service (QoS), radio policies, and other wireless network parameters. Up to 16 access point WLANs can be configured per controller.

Note Chapter 6 provides instructions for configuring WLANs.

Figure 3-4 illustrates the relationship between ports, interfaces, and WLANs.

Figure 3-4 Ports, Interfaces, and WLANs



As shown in Figure 3-4, each controller port connection is an 802.1Q trunk and should be configured as such on the neighbor switch. On Cisco switches, the native VLAN of an 802.1Q trunk is an untagged VLAN. Therefore, if you configure an interface to use the native VLAN on a neighboring Cisco switch, make sure you configure the interface on the controller to be untagged.

Note A zero value for the VLAN identifier (on the Controller > Interfaces page) means that the interface is untagged.

The default (untagged) native VLAN on Cisco switches is VLAN 1. When controller interfaces are configured as tagged (meaning that the VLAN identifier is set to a non-zero value), the VLAN must be allowed on the 802.1Q trunk configuration on the neighbor switch and not be the native untagged VLAN.

Cisco recommends that only tagged VLANs be used on the controller. You should also allow only relevant VLANs on the neighbor switch's 802.1Q trunk connections to controller ports. All other VLANs should be disallowed or pruned in the switch port trunk configuration. This practice is extremely important for optimal performance of the controller.

Note Cisco recommends that you assign one set of VLANs for WLANs and a different set of VLANs for management interfaces to ensure that controllers properly route VLAN traffic.

Follow the instructions on the pages indicated to configure your controller's interfaces and ports:

- Configuring the Management, AP-Manager, Virtual, and Service-Port Interfaces, page 3-9
- Configuring Dynamic Interfaces, page 3-14
- Configuring Ports, page 3-17
- Enabling Link Aggregation, page 3-27
- Configuring a 4400 Series Controller to Support More Than 48 Access Points, page 3-30

Configuring the Management, AP-Manager, Virtual, and Service-Port Interfaces

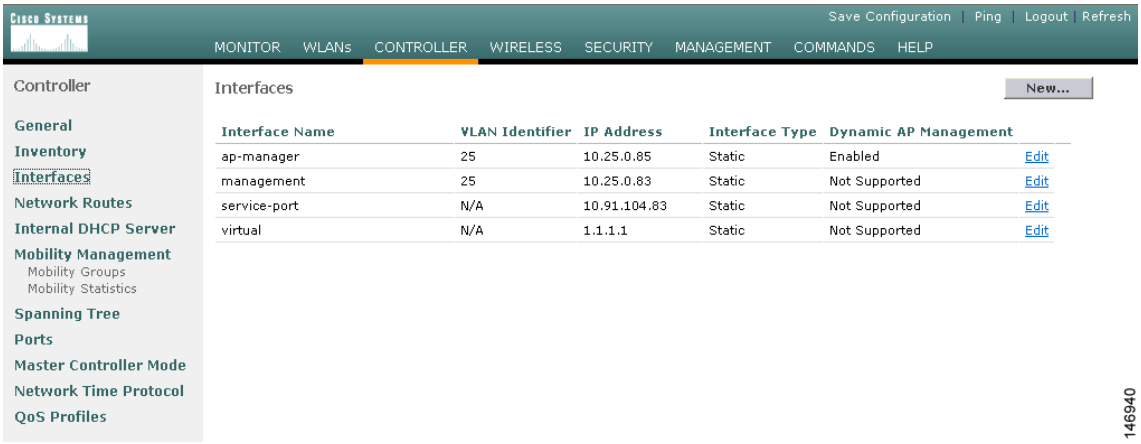
Typically, you define the management, AP-manager, virtual, and service-port interface parameters using the Startup Wizard. However, you can display and configure interface parameters through either the GUI or CLI after the controller is running.

Using the GUI to Configure the Management, AP-Manager, Virtual, and Service-Port Interfaces

Follow these steps to display and configure the management, AP-manager, virtual, and service-port interface parameters using the GUI.

Step 1 Click **Controller** > **Interfaces** to access the Interfaces page (see Figure 3-5).

Figure 3-5 Interfaces Page



This page shows the current controller interface settings.

Step 2 If you want to modify the settings of a particular interface, click the interface's **Edit** link. The Interfaces > Edit page for that interface appears.

Step 3 Configure the following parameters for each interface type:

Management Interface

Note The management interface uses the controller's factory-set distribution system MAC address.

- VLAN identifier

  Note Enter **0** for an untagged VLAN or a non-zero value for a tagged VLAN. Cisco recommends that only tagged VLANs be used on the controller.

- Fixed IP address, IP netmask, and default gateway
- Physical port assignment
- Primary and secondary DHCP servers
- Access control list (ACL) setting, if required

  Note To create ACLs, follow the instructions in Chapter 5.

AP-Manager Interface

- VLAN identifier

Note Enter **0** for an untagged VLAN or a non-zero value for a tagged VLAN. Cisco recommends that only tagged VLANs be used on the controller.

- Fixed IP address, IP netmask, and default gateway

Note The AP-manager interface's IP address must be different from the management interface's IP address but must be on the same subnet as the management interface.

- Physical port assignment
- Primary and secondary DHCP servers
- Access control list (ACL) name, if required

Note To create ACLs, follow the instructions in Chapter 5.

Virtual Interface

- Any fictitious, unassigned, and unused gateway IP address, such as 1.1.1.1
- DNS gateway host name

Service-Port Interface

Note The service-port interface uses the controller's factory-set service-port MAC address.

- DHCP protocol (enabled) or
- DHCP protocol (disabled) and IP address and IP netmask

Step 4 Click **Save Configuration** to save your changes.

Step 5 If you made any changes to the virtual interface, reboot the controller so your changes take effect.

Using the CLI to Configure the Management, AP-Manager, Virtual, and Service-Port Interfaces

This section provides instructions for displaying and configuring the management, AP-manager, virtual, and service-port interfaces using the CLI.

Using the CLI to Configure the Management Interface

Follow these steps to display and configure the management interface parameters using the CLI.

Step 1 Enter **show interface detailed management** to view the current management interface settings.

Note The management interface uses the controller's factory-set distribution system MAC address.

Step 2 Enter **config wlan disable** *wlan-number* to disable each WLAN that uses the management interface for distribution system communication.

Step 3 Enter these commands to define the management interface:

- **config interface address management** *ip-addr ip-netmask gateway*
- **config interface vlan management** {*vlan-id* | **0**}

Note Enter **0** for an untagged VLAN or a non-zero value for a tagged VLAN. Cisco recommends that only tagged VLANs be used on the controller.

- **config interface port management** *physical-ds-port-number*
- **config interface dhcp management** *ip-address-of-primary-dhcp-server* [*ip-address-of-secondary-dhcp-server*]
- **config interface acl management** *access-control-list-name*

Note To create ACLs, follow the instructions in Chapter 5.

Step 4 Enter **show interface detailed management** to verify that your changes have been saved.

Using the CLI to Configure the AP-Manager Interface

Follow these steps to display and configure the AP-manager interface parameters using the CLI.

Step 1 Enter **show interface summary** to view the current interfaces.

Note If the system is operating in Layer 2 mode, the AP-manager interface is not listed.

Step 2 Enter **show interface detailed ap-manager** to view the current AP-manager interface settings.

Step 3 Enter **config wlan disable** *wlan-number* to disable each WLAN that uses the AP-manager interface for distribution system communication.

Step 4 Enter these commands to define the AP-manager interface:

- **config interface address ap-manager** *ip-addr ip-netmask gateway*
- **config interface vlan ap-manager** {*vlan-id* | **0**}

Note Enter **0** for an untagged VLAN or a non-zero value for a tagged VLAN. Cisco recommends that only tagged VLANs be used on the controller.

- **config interface port ap-manager** *physical-ds-port-number*
- **config interface dhcp ap-manager** *ip-address-of-primary-dhcp-server* [*ip-address-of-secondary-dhcp-server*]
- **config interface acl ap-manager** *access-control-list-name*

Note To create ACLs, follow the instructions in Chapter 5.

Step 5 Enter **show interface detailed ap-manager** to verify that your changes have been saved.

Using the CLI to Configure the Virtual Interface

Follow these steps to display and configure the virtual interface parameters using the CLI.

Step 1 Enter **show interface detailed virtual** to view the current virtual interface settings.

Step 2 Enter **config wlan disable** *wlan-number* to disable each WLAN that uses the virtual interface for distribution system communication.

Step 3 Enter these commands to define the virtual interface:

- **config interface address virtual** *ip-address*

Note For *ip-address*, enter any fictitious, unassigned, and unused gateway IP address, such as 1.1.1.1.

- **config interface hostname virtual** *dns-host-name*

Step 4 Enter **reset system**. At the confirmation prompt, enter **Y** to save your configuration changes to NVRAM. The controller reboots.

Step 5 Enter **show interface detailed virtual** to verify that your changes have been saved.

Using the CLI to Configure the Service-Port Interface

Follow these steps to display and configure the service-port interface parameters using the CLI.

Step 1 Enter **show interface detailed service-port** to view the current service-port interface settings.

Note The service-port interface uses the controller's factory-set service-port MAC address.

Step 2 Enter these commands to define the service-port interface:

- To configure the DHCP server: **config interface dhcp service-port** *ip-address-of-primary-dhcp-server* [*ip-address-of-secondary-dhcp-server*]
- To disable the DHCP server: **config interface dhcp service-port none**
- To configure the IP address: **config interface address service-port** *ip-addr ip-netmask gateway*

Step 3 The service port is used for out-of-band management of the controller. If the management workstation is in a remote subnet, you may need to add a route on the controller in order to manage the controller from that remote workstation. To do so, enter this command:

config route *network-ip-addr ip-netmask gateway*

Step 4 Enter **show interface detailed service-port** to verify that your changes have been saved.

Configuring Dynamic Interfaces

This section provides instructions for configuring dynamic interfaces using either the GUI or CLI.

Using the GUI to Configure Dynamic Interfaces

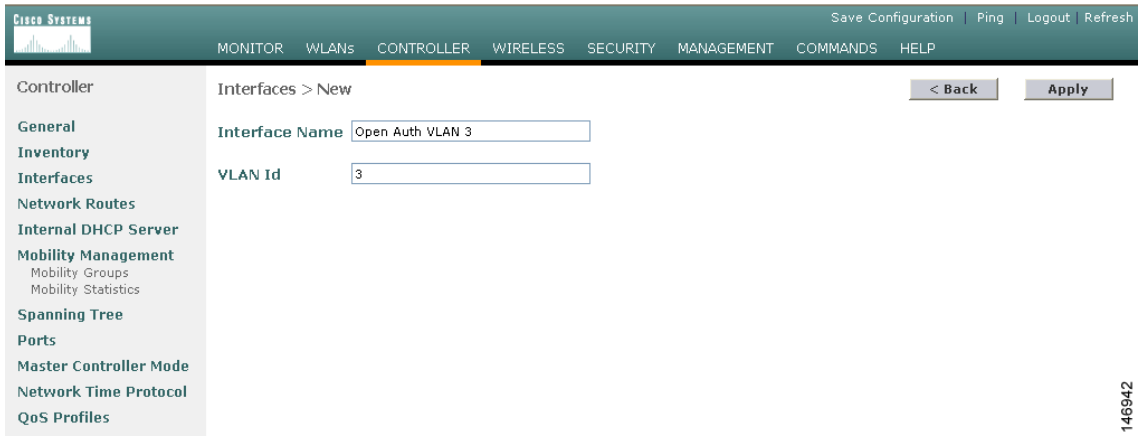
Follow these steps to create new or edit existing dynamic interfaces using the GUI.

Step 1 Click **Controller** > **Interfaces** to access the Interfaces page (see Figure 3-5).

Step 2 Perform one of the following:

- To create a new dynamic interface, click **New**. The Interfaces > New page appears (see Figure 3-6). Go to Step 3.
- To modify the settings of an existing dynamic interface, click the interface's **Edit** link. The Interfaces > Edit page for that interface appears (see Figure 3-7). Go to Step 5.
- To delete an existing dynamic interface, click the interface's **Remove** link.

Figure 3-6 Interfaces > New Page

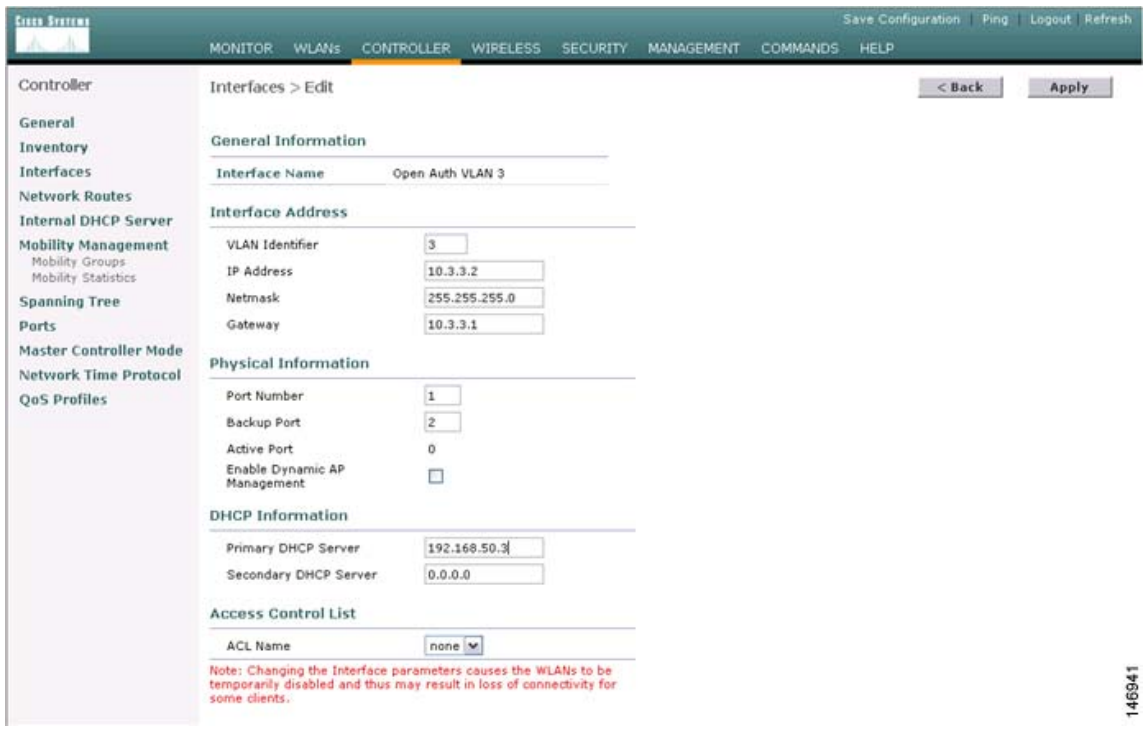


Step 3 Enter an interface name and a VLAN identifier, as shown in Figure 3-6.

Note Enter a non-zero value for the VLAN identifier. Tagged VLANs must be used for dynamic interfaces.

Step 4 Click **Apply** to commit your changes. The Interfaces > Edit page appears (see Figure 3-7).

Figure 3-7 Interfaces > Edit Page



Step 5 Configure the following parameters:

- VLAN identifier
- Fixed IP address, IP netmask, and default gateway
- Physical port assignment
- Primary and secondary DHCP servers
- Access control list (ACL) name, if required

Note To create ACLs, follow the instructions in Chapter 5.

Note To ensure proper operation, you must set the Port Number and Primary DHCP Server parameters.

Step 6 Click **Save Configuration** to save your changes.

Step 7 Repeat this procedure for each dynamic interface that you want to create or edit.

Using the CLI to Configure Dynamic Interfaces

Follow these steps to configure dynamic interfaces using the CLI.

Step 1 Enter **show interface summary** to view the current dynamic interfaces.

Step 2 To view the details of a specific dynamic interface, enter **show interface detailed** *operator-defined-interface-name*.

Step 3 Enter **config wlan disable** *wlan-number* to disable each WLAN that uses the dynamic interface for distribution system communication.

Step 4 Enter these commands to configure dynamic interfaces:

- **config interface create** *operator-defined-interface-name* {*vlan-id* | ***x***}

Note Enter a non-zero value for the VLAN identifier. Tagged VLANs must be used for dynamic interfaces.

- **config interface address** *operator-defined-interface-name ip-addr ip-netmask* [*gateway*]
- **config interface vlan** *operator-defined-interface-name* {*vlan-id* | **0**}
- **config interface port** *operator-defined-interface-name physical-ds-port-number*
- **config interface dhcp** *operator-defined-interface-name ip-address-of-primary-dhcp-server* [*ip-address-of-secondary-dhcp-server*]
- **config interface acl** *operator-defined-interface-name access-control-list-name*

Note To create ACLs, follow the instructions in Chapter 5.

Step 5 Enter **show interface detailed** *operator-defined-interface-name* and **show interface summary** to verify that your changes have been saved.

Note If desired, you can enter **config interface delete** *operator-defined-interface-name* to delete a dynamic interface.

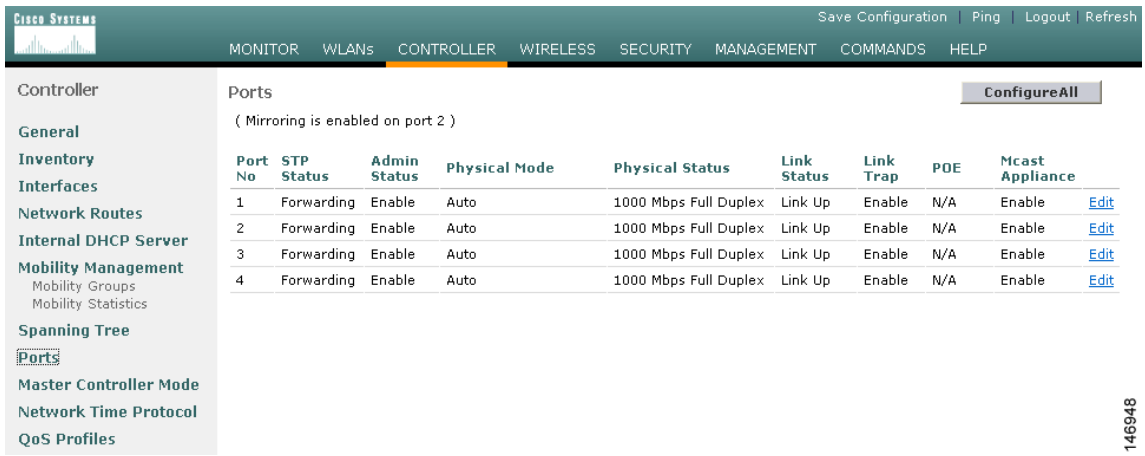
Configuring Ports

The controller's ports are preconfigured with factory default settings designed to make the controllers' ports operational without additional configuration. However, you can view the status of the controller's ports and edit their configuration parameters at any time.

Follow these steps to use the GUI to view the status of the controller's ports and make any configuration changes if necessary.

Step 1 Click **Controller** > **Ports** to access the Ports page (see Figure 3-8).

Figure 3-8 Ports Page



This page shows the current configuration for each of the controller's ports.

Step 2 If you want to change the settings of any port, click the **Edit** link for that specific port. The Port > Configure page appears (see Figure 3-9).

Note The number of parameters available on the Port > Configure page depends on your controller type. For instance, Cisco 2000 series controllers and the controller in a Cisco Integrated Services Router have fewer configurable parameters than a Cisco 4400 series controller, which is shown in Figure 3-9.

Figure 3-9 Port > Configure Page

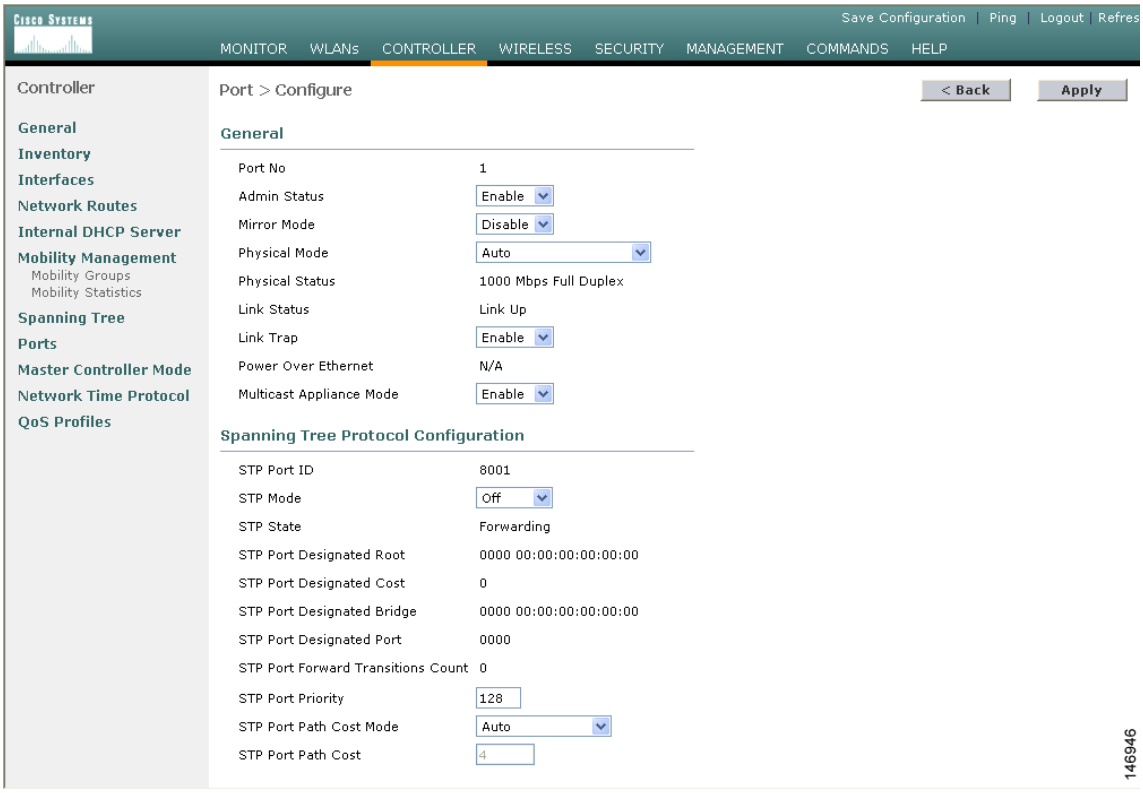


Table 3-2 interprets the current status of the port.

Table 3-2 Port Status

Parameter	Description	
Port Number	The number of the current port.	
Physical Status	The data rate being used by the port. The available data rates vary based on controller type.	
	Controller	**Available Data Rates**
	4400 and 4100 series	1000 Mbps full duplex
	2000 series	10 or 100 Mbps, half or full duplex
	WiSM	1000 Mbps full duplex
	Integrated Services Routers	100 Mbps full duplex
Link Status	The port's link status. **Values:** Link Up or Link Down	

Table 3-2 Port Status

Parameter	Description
Power Over Ethernet (PoE)	Determines if the connecting device is equipped to receive power through the Ethernet cable and if so provides -48 VDC. **Values:** Enable or Disable **Note** Some older Cisco access points do not draw PoE even if it is enabled on the controller port. In such cases, contact the Cisco Technical Assistance Center (TAC).

Step 3 Table 3-3 lists and describes the port's configurable parameters. Follow the instructions in the table to make any desired changes.

Table 3-3 Port Parameters

Parameter	Description
Admin Status	Enables or disables the flow of traffic through the port. **Options:** Enable or Disable **Default:** Enable **Note** Administratively disabling the port does not affect the port's link status.The link can be brought down only by other Cisco devices.
Physical Mode	Determines whether the port's data rate is set automatically or specified by the user. The supported data rates vary based on controller type. **Default:** Auto

Controller	Supported Data Rates
4400 and 4100 series	Auto or 1000 Mbps full duplex
2000 series	Auto or 10 or 100 Mbps, half or full duplex
WiSM	Auto or 1000 Mbps full duplex
Integrated Services Routers	Auto or 100 Mbps full duplex

Link Trap	Causes the port to send a trap when the port's link status changes. **Options:** Enable or Disable **Default:** Enable
Multicast Appliance Mode	Enables or disables the multicast appliance service for this port. **Options:** Enable or Disable **Default:** Enable

Step 4 Click **Save Configuration** to save your changes.

Step 5 Click **Back** to return to the Ports page and review your changes.

Step 6 Repeat this procedure for each additional port that you want to configure.

Step 7 Go to the following sections if you want to configure the controller's ports for these advanced features:

- Port mirroring, see below
- Spanning Tree Protocol (STP), page 3-21

Configuring Port Mirroring

Mirror mode enables you to duplicate to another port all of the traffic originating from or terminating at a single client device or access point. It is useful in diagnosing specific network problems. Mirror mode should be enabled only on an unused port as any connections to this port become unresponsive.

Note 4100 series and WiSM controllers do not support mirror mode. Also, a controller's service port cannot be used as a mirrored port.

Note Port mirroring is not supported when link aggregation (LAG) is enabled on the controller.

Note Cisco recommends that you do not mirror traffic from one controller port to another as this setup could cause network problems.

Follow these steps to enable port mirroring.

Step 1 Click **Controller** > **Ports** to access the Ports page (see Figure 3-8).

Step 2 Click **Edit** for the unused port for which you want to enable mirror mode. The Port > Configure page appears (see Figure 3-9).

Step 3 Set the Mirror Mode parameter to **Enable**.

Step 4 Click **Save Configuration** to save your changes.

Step 5 Perform one of the following:

- Follow these steps if you want to choose a specific client device that will mirror its traffic to the port you selected on the controller:
  - **a.** Click **Wireless** > **Clients** to access the Clients page.
  - **b.** Click **Detail** for the client on which you want to enable mirror mode. The Clients > Detail page appears.
  - **c.** Under Client Details, set the Mirror Mode parameter to **Enable**.
- Follow these steps if you want to choose an access point that will mirror its traffic to the port you selected on the controller:
  - **a.** Click **Wireless** > **All APs** to access the All APs page.

b. Click **Detail** for the access point on which you want to enable mirror mode. The All APs > Details page appears.

c. Under General, set the Mirror Mode parameter to **Enable**.

Step 6 Click **Save Configuration** to save your changes.

Configuring Spanning Tree Protocol

Spanning Tree Protocol (STP) is a Layer 2 link management protocol that provides path redundancy while preventing loops in the network. For a Layer 2 Ethernet network to function properly, only one active path can exist between any two network devices. STP allows only one active path at a time between network devices but establishes redundant links as a backup if the initial link should fail.

The spanning-tree algorithm calculates the best loop-free path throughout a Layer 2 network. Infrastructure devices such as controllers and switches send and receive spanning-tree frames, called *bridge protocol data units (BPDUs)*, at regular intervals. The devices do not forward these frames but use them to construct a loop-free path.

Multiple active paths among end stations cause loops in the network. If a loop exists in the network, end stations might receive duplicate messages. Infrastructure devices might also learn end-station MAC addresses on multiple Layer 2 interfaces. These conditions result in an unstable network.

STP defines a tree with a root bridge and a loop-free path from the root to all infrastructure devices in the Layer 2 network.

Note STP discussions use the term *root* to describe two concepts: the controller on the network that serves as a central point in the spanning tree is called the *root bridge*, and the port on each controller that provides the most efficient path to the root bridge is called the *root port*. The root bridge in the spanning tree is called the *spanning-tree root*.

STP forces redundant data paths into a standby (blocked) state. If a network segment in the spanning tree fails and a redundant path exists, the spanning-tree algorithm recalculates the spanning-tree topology and activates the standby path.

When two ports on a controller are part of a loop, the spanning-tree port priority and path cost settings determine which port is put in the forwarding state and which is put in the blocking state. The port priority value represents the location of a port in the network topology and how well it is located to pass traffic. The path cost value represents media speed.

The controller maintains a separate spanning-tree instance for each active VLAN configured on it. A *bridge ID*, consisting of the bridge priority and the controller's MAC address, is associated with each instance. For each VLAN, the controller with the lowest controller ID becomes the spanning-tree root for that VLAN.

STP is disabled for the controller's distribution system ports by default. The following sections provide instructions for configuring STP for your controller using either the GUI or CLI.

Using the GUI to Configure Spanning Tree Protocol

Follow these steps to configure STP using the GUI.

Step 1 Click **Controller** > **Ports** to access the Ports page (see Figure 3-8).

Step 2 Click **Edit** for the specific port for which you want to configure STP. The Port > Configure page appears (see Figure 3-9). This page shows the STP status of the port and enables you to configure STP parameters.

Table 3-4 interprets the current STP status of the port.

Table 3-4 Port Spanning Tree Status

Parameter	Description	
STP Port ID	The number of the port for which STP is enabled or disabled.	
STP State	The port's current STP state. It controls the action that a port takes upon receiving a frame. **Values:** Disabled, Blocking, Listening, Learning, Forwarding, and Broken	
	STP State	**Description**
	Disabled	The port is not participating in spanning tree because the port is shut down, the link is down, or STP is not enabled for this port.
	Blocking	The port does not participate in frame forwarding.
	Listening	The first transitional state after the blocking state when STP determines that the port should participate in frame forwarding.
	Learning	The port prepares to participate in frame forwarding.
	Forwarding	The port forwards frames.
	Broken	The port is malfunctioning.
STP Port Designated Root	The unique identifier of the root bridge in the configuration BPDUs.	
STP Port Designated Cost	The path cost of the designated port.	
STP Port Designated Bridge	The identifier of the bridge that the port considers to be the designated bridge for this port.	
STP Port Designated Port	The port identifier on the designated bridge for this port.	
STP Port Forward Transitions Count	The number of times that the port has transitioned from the learning state to the forwarding state.	

Step 3 Table 3-5 lists and describes the port's configurable STP parameters. Follow the instructions in the table to make any desired changes.

Table 3-5 Port Spanning Tree Parameters

<table>
<tr><th>Parameter</th><th>Description</th></tr>
<tr><td>STP Mode</td><td>The STP administrative mode associated with this port.
Options: Off, 802.1D, or Fast
Default: Off

<table><tr><th>STP Mode</th><th>Description</th></tr><tr><td>Off</td><td>Disables STP for this port.</td></tr><tr><td>802.1D</td><td>Enables this port to participate in the spanning tree and go through all of the spanning tree states when the link state transitions from down to up.</td></tr><tr><td>Fast</td><td>Enables this port to participate in the spanning tree and puts it in the forwarding state when the link state transitions from down to up more quickly than when the STP mode is set to 802.1D.
Note In this state, the forwarding delay timer is ignored on link up.</td></tr></table></td></tr>
<tr><td>STP Port Priority</td><td>The location of the port in the network topology and how well the port is located to pass traffic.
Range: 0 to 255
Default: 128</td></tr>
<tr><td>STP Port Path Cost Mode</td><td>Determines whether the STP port path cost is set automatically or specified by the user. If you choose User Configured, you also need to set a value for the STP Port Path Cost parameter.
Range: Auto or User Configured
Default: Auto</td></tr>
<tr><td>STP Port Path Cost</td><td>The speed at which traffic is passed through the port. This parameter must be set if the STP Port Path Cost Mode parameter is set to User Configured.
Options: 0 to 65535
Default: 0, which causes the cost to be adjusted for the speed of the port when the link comes up.
Note Typically, a value of 100 is used for 10-Mbps ports and 19 for 100-Mbps ports.</td></tr>
</table>

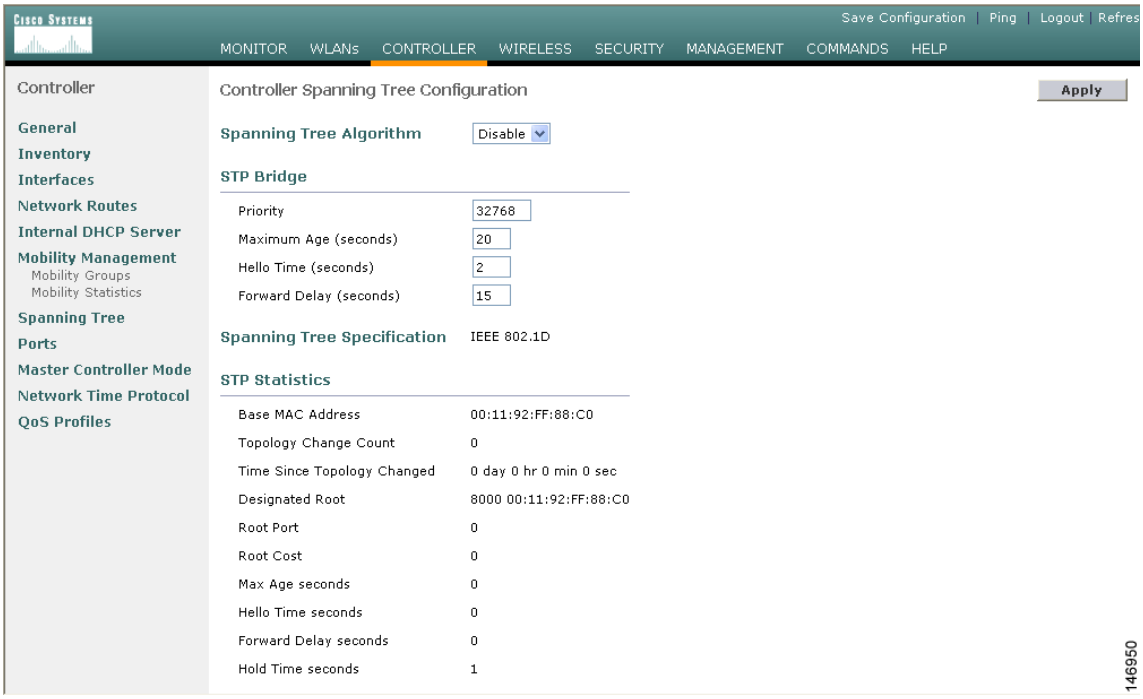
Step 4 Click **Save Configuration** to save your changes.

Step 5 Click **Back** to return to the Ports page.

Step 6 Repeat Step 2 through Step 5 for each port for which you want to enable STP.

Step 7 Click **Controller** > **Spanning Tree** to access the Controller Spanning Tree Configuration page (see Figure 3-10).

Figure 3-10 Controller Spanning Tree Configuration Page



This page allows you to enable or disable the spanning tree algorithm for the controller, modify its characteristics, and view the STP status.Table 3-6 interprets the current STP status for the controller.

Table 3-6 Controller Spanning Tree Status

Parameter	Description
Spanning Tree Specification	The STP version being used by the controller. Currently, only an IEEE 802.1D implementation is available.
Base MAC Address	The MAC address used by this bridge when it must be referred to in a unique fashion. When it is concatenated with dot1dStpPriority, a unique bridge identifier is formed that is used in STP.
Topology Change Count	The total number of topology changes detected by this bridge since the management entity was last reset or initialized.
Time Since Topology Changed	The time (in days, hours, minutes, and seconds) since a topology change was detected by the bridge.
Designated Root	The bridge identifier of the spanning tree root. This value is used as the Root Identifier parameter in all configuration BPDUs originated by this node.
Root Port	The number of the port that offers the lowest cost path from this bridge to the root bridge.
Root Cost	The cost of the path to the root as seen from this bridge.

Table 3-6 Controller Spanning Tree Status (continued)

Parameter	Description
Max Age (seconds)	The maximum age of STP information learned from the network on any port before it is discarded.
Hello Time (seconds)	The amount of time between the transmission of configuration BPDUs by this node on any port when it is the root of the spanning tree or trying to become so. This is the actual value that this bridge is currently using.
Forward Delay (seconds)	This value controls how fast a port changes its spanning tree state when moving toward the forwarding state. It determines how long the port stays in each of the listening and learning states that precede the forwarding state. This value is also used, when a topology change has been detected and is underway, to age all dynamic entries in the forwarding database. **Note** This is the actual value that this bridge is currently using, in contrast to *Stp Bridge Forward Delay*, which is the value that this bridge and all others would start using if this bridge were to become the root.
Hold Time (seconds)	The minimum time period to elapse between the transmission of configuration BPDUs through a given LAN port. **Note** At most, one configuration BPDU can be transmitted in any hold time period.

Step 8 Table 3-7 lists and describes the controller's configurable STP parameters. Follow the instructions in the table to make any desired changes.

Table 3-7 Controller Spanning Tree Parameters

Parameter	Description
Spanning Tree Algorithm	Enables or disables STP for the controller. **Options:** Enable or Disable **Default:** Disable
Priority	The location of the controller in the network topology and how well the controller is located to pass traffic. **Range:** 0 to 65535 **Default:** 32768
Maximum Age (seconds)	The length of time that the controller stores protocol information received on a port. **Range:** 6 to 40 seconds **Default:** 20 seconds

Table 3-7 Controller Spanning Tree Parameters (continued)

Parameter	Description
Hello Time (seconds)	The length of time that the controller broadcasts hello messages to other controllers. **Options:** 1 to 10 seconds **Default:** 2 seconds
Forward Delay (seconds)	The length of time that each of the listening and learning states lasts before the port begins forwarding. **Options:** 4 to 30 seconds **Default:** 15 seconds

Step 9 Click **Save Configuration** to save your changes.

Using the CLI to Configure Spanning Tree Protocol

Follow these steps to configure STP using the CLI.

Step 1 Enter **show spanningtree port** and **show spanningtree switch** to view the current STP status.

Step 2 If STP is enabled, you must disable it before you can change STP settings. Enter **config spanningtree switch mode disable** to disable STP on all ports.

Step 3 Enter one of these commands to configure the STP port administrative mode:

- **config spanningtree port mode 802.1d** {*port-number* | **all**}
- **config spanningtree port mode fast** {*port-number* | **all**}
- **config spanningtree port mode off** {*port-number* | **all**}

Step 4 Enter one of these commands to configure the STP port path cost on the STP ports:

- **config spanningtree port pathcost** *1-65535* {*port-number* | **all**}—Specifies a path cost from 1 to 65535 to the port.
- **config spanningtree port mode pathcost auto** {*port-number* | **all**}—Enables the STP algorithm to automatically assign the path cost. This is the default setting.

Step 5 Enter **config spanningtree port priority** *0-255 port-number* to configure the port priority on STP ports. The default priority is 128.

Step 6 If necessary, enter **config spanningtree switch bridgepriority** *0-65535* to configure the controller's STP bridge priority. The default bridge priority is 32768.

Step 7 If necessary, enter **config spanningtree switch forwarddelay** *4-30* to configure the controller's STP forward delay in seconds. The default forward delay is 15 seconds.

Step 8 If necessary, enter **config spanningtree switch hellotime** *1-10* to configure the controller's STP hello time in seconds. The default hello time is 2 seconds.

Step 9 If necessary, enter **config spanningtree switch maxage** *6-40* to configure the controller's STP maximum age. The default maximum age is 20 seconds.

Step 10 After you configure STP settings for the ports, enter **config spanningtree switch mode enable** to enable STP for the controller. The controller automatically detects logical network loops, places redundant ports on standby, and builds a network with the most efficient pathways.

Step 11 Enter **show spanningtree port** and **show spanningtree switch** to verify that your changes have been saved.

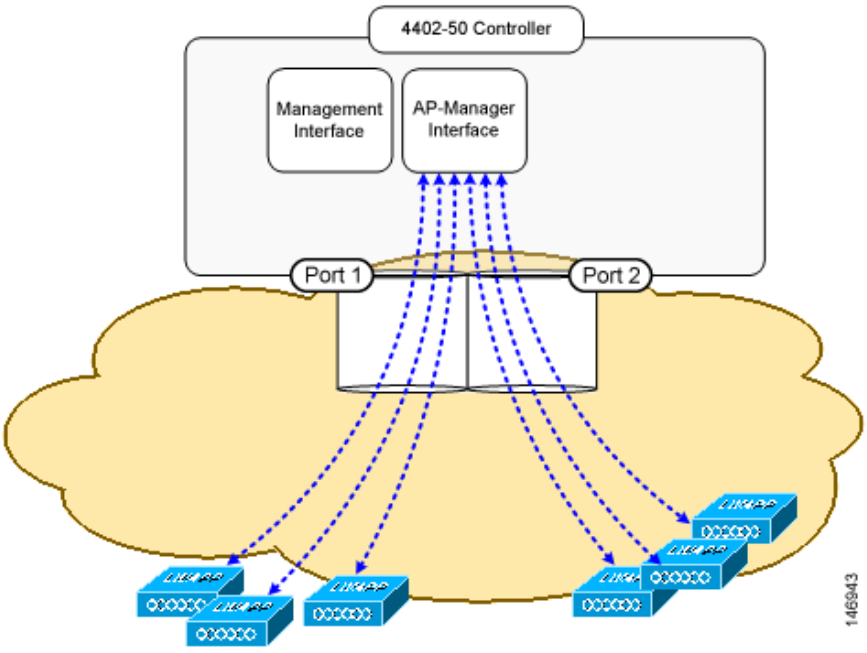
Enabling Link Aggregation

Link aggregation (LAG) is a partial implementation of the 802.3ad port aggregation standard. It bundles all of the controller's distribution system ports into a single 802.3ad port channel, thereby reducing the number of IP addresses needed to configure the ports on your controller. When LAG is enabled, the system dynamically manages port redundancy and load balances access points transparently to the user.

Cisco 4400 series controllers support LAG in software release 3.2 and higher, and LAG is enabled automatically on the Cisco WiSM controllers. Without LAG, each distribution system port on the controller supports up to 48 access points. With LAG enabled, a 4402 controller's logical port supports up to 50 access points, a 4404 controller's logical port supports up to 100 access points, and the logical port on each Cisco WiSM controller supports up to 150 access points.

Figure 3-11 illustrates LAG.

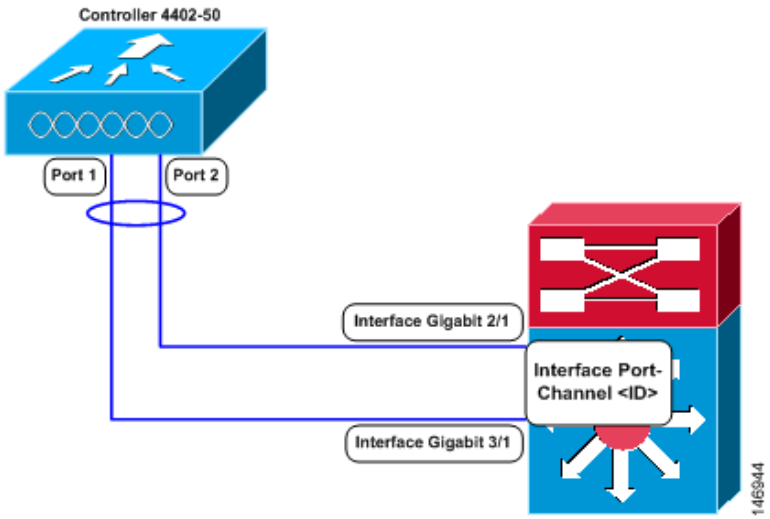
Figure 3-11 Link Aggregation



LAG simplifies controller configuration because you no longer need to configure primary and secondary ports for each interface. If any of the controller ports fail, traffic is automatically migrated to one of the other ports. As long as at least one controller port is functioning, the system continues to operate, access points remain connected to the network, and wireless clients continue to send and receive data.

When configuring bundled ports, you may want to consider spanning modules with your port channel when you connect to a modular switch such as the Catalyst 6500. This practice provides protection in the case of a module failure. Figure 3-12 illustrates a scenario where a 4402-50 controller is connected to a Catalyst 6500 with gigabit modules in slots 2 and 3. The controller's port 1 is connected to gigabit interface 3/1, and the controller's port 2 is connected to gigabit interface 2/1 on the Catalyst 6500. On the Catalyst switch, the two interfaces are assigned to the same channel group.

Figure 3-12 Link Aggregation with Catalyst 6500 Neighbor Switch



Link Aggregation Guidelines

Keep these guidelines in mind when using LAG:

- You cannot configure the controller's ports into separate LAG groups. Only one LAG group is supported per controller. Therefore, you can connect a controller in LAG mode to only one neighbor device.
- When LAG is enabled, any change to the LAG configuration requires a controller reboot.
- When you enable LAG, you can configure only one AP-manager interface because only one logical port is needed.
- When you enable LAG, all dynamic AP-manager interfaces and untagged interfaces are deleted, and all WLANs are disabled and mapped to the management interface.
- When you enable LAG, you cannot create interfaces with a primary port other than 29.
- When you enable LAG, all ports participate in LAG by default. Therefore, you must configure LAG for all of the connected ports in the neighbor switch.
- When you enable LAG, port mirroring is not supported.
- Make sure the port-channel on the switch is configured for the IEEE standard Link Aggregation Control Protocol (LACP), not the Cisco proprietary Port Aggregation Protocol (PAgP).
- When you disable LAG, you must configure primary and secondary ports for all interfaces.
- When you disable LAG, you must assign an AP-manager interface to each port on the controller.

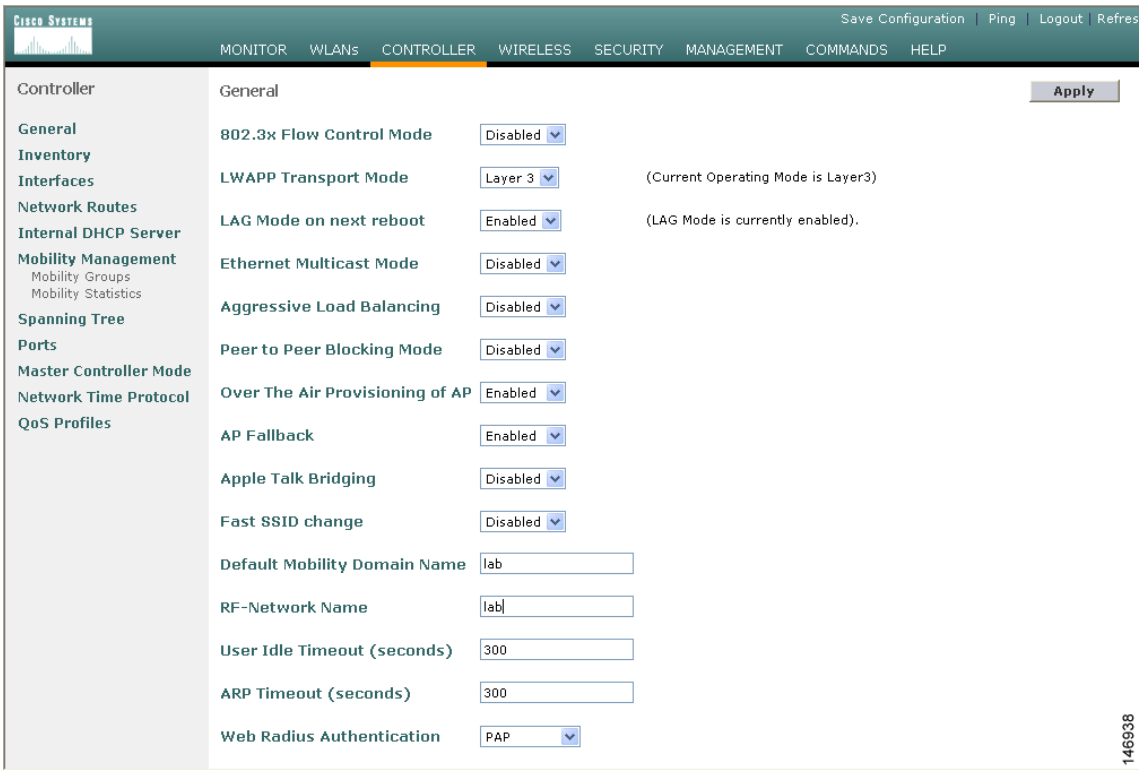
LAG is typically configured using the Startup Wizard, but you can enable or disable it at any time through either the GUI or CLI.

Using the GUI to Enable Link Aggregation

Follow these steps to enable LAG on your controller using the GUI.

Step 1 Click **Controller > General** to access the General page (see Figure 3-13).

Figure 3-13 General Page



Step 2 Set the LAG Mode on Next Reboot parameter to **Enabled**.

Note Choose **Disabled** if you want to disable LAG.

Step 3 Click **Save Configuration** to save your changes.

Step 4 Reboot the controller.

Using the CLI to Enable Link Aggregation

Follow these steps to enable LAG on your controller using the CLI.

Step 1 Enter **config lag enable** to enable LAG.

Note Enter **config lag disable** if you want to disable LAG.

Step 2 Enter **show lag** to verify that your change has been saved.

Step 3 Reboot the controller.

Configuring Neighbor Devices to Support LAG

The controller's neighbor devices must also be properly configured to support LAG.

- Each neighbor port to which the controller is connected should be configured as follows:

```
interface GigabitEthernet <interface id>
    switchport
    channel-group <id> mode on
    no shutdown
```

- The port channel on the neighbor switch should be configured as follows:

```
interface port-channel <id>
    switchport
    switchport trunk encapsulation dot1q
    switchport trunk native vlan <native vlan id>
    switchport trunk allowed vlan <allowed vlans>
    switchport mode trunk
    no shutdown
```

Configuring a 4400 Series Controller to Support More Than 48 Access Points

As noted earlier, 4400 series controllers can support up to 48 access points per port. However, you can configure your 4400 series controller to support more access points using one of the following methods:

- Link aggregation (for controllers in Layer 3 mode), page 3-31
- Multiple AP-manager interfaces (for controllers in Layer 3 mode), page 3-31
- Connecting additional ports (for controllers in Layer 2 mode), page 3-36

Follow the instructions on the page indicated for the method you want to use.

The following factors should help you decide which method to use if your controller is set for Layer 3 operation:

- With link aggregation, all of the controller ports need to connect to the same neighbor switch. If the neighbor switch goes down, the controller loses connectivity.
- With multiple AP-manager interfaces, you can connect your ports to different neighbor devices. If one of the neighbor switches goes down, the controller still has connectivity. However, using multiple AP-manager interfaces presents certain challenges (as discussed in the "Using Multiple AP-Manager Interfaces" section below) when port redundancy is a concern.

Using Link Aggregation

See the "Enabling Link Aggregation" section on page 3-27 for more information and instructions on enabling link aggregation.

Note Link aggregation is the only method that can be used for the Cisco WiSM controllers.

Using Multiple AP-Manager Interfaces

Note This method can be used only with Cisco 4400 series stand-alone controllers.

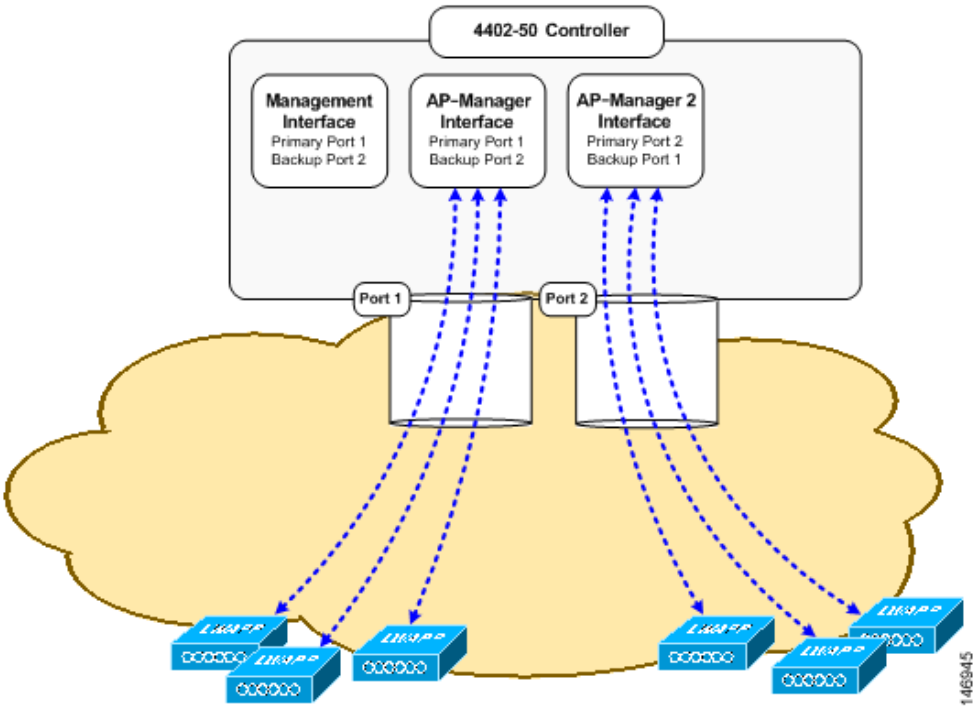
When you create two or more AP-manager interfaces, each one is mapped to a different port (see Figure 3-14). The ports should be configured in sequential order such that AP-manager interface 2 is on port 2, AP-manager interface 3 is on port 3, and AP-manager interface 4 is on port 4. In addition, all AP-manager interfaces must be on the same VLAN or IP subnet, and they may or may not be on the same VLAN or IP subnet as the management interface.

Note You must assign an AP-manager interface to each port on the controller.

Before an access point joins a controller, it sends out a discovery request. From the discovery response that it receives, the access point can tell the number of AP-manager interfaces on the controller and the number of access points on each AP-manager interface. The access point generally joins the AP-manager with the least number of access points. In this way, the access point load is dynamically distributed across the multiple AP-manager interfaces.

Note Access points may not be distributed completely evenly across all of the AP-manager interfaces, but a certain level of load balancing occurs.

Figure 3-14 Two AP-Manager Interfaces



Note Cisco recommends that you configure all AP-manager interfaces on the same VLAN and IP subnet.

Before implementing multiple AP-manager interfaces, you should consider how they would impact your controller's port redundancy.

Examples:

1. The 4402-50 controller supports a maximum of 50 access points and has two ports. To support the maximum number of access points, you would need to create two AP-manager interfaces. A problem arises, however, if you want to support port redundancy. As shown in Figure 3-14, the static AP-manager interface has port 1 assigned as the primary port and port 2 as the secondary, or backup, port. The second AP-manager interface has port 2 assigned as the primary and port 1 as the secondary. If either port fails, the controller would be left trying to support 50 access points on a port that supports only 48. As a result, two access points would be unable to communicate with the controller and would be forced to look for an alternate controller.
2. The 4404-100 controller supports up to 100 access points and has four ports. To support the maximum number of access points, you would need to create three (or more) AP-manager interfaces. Figure 3-15 illustrates three AP-manager interfaces, each with a unique primary port and sharing the same secondary port. If the primary port of one of the AP-manager interfaces fails, the controller clears the access points' state, and the access points must reboot to reestablish communication with the controller using the normal controller join process. The controller no longer includes the failed AP-manager interface in the LWAPP discovery responses. The access points then rejoin the controller and are load balanced among the available AP-manager interfaces.

Figure 3-15 Three AP-Manager Interfaces

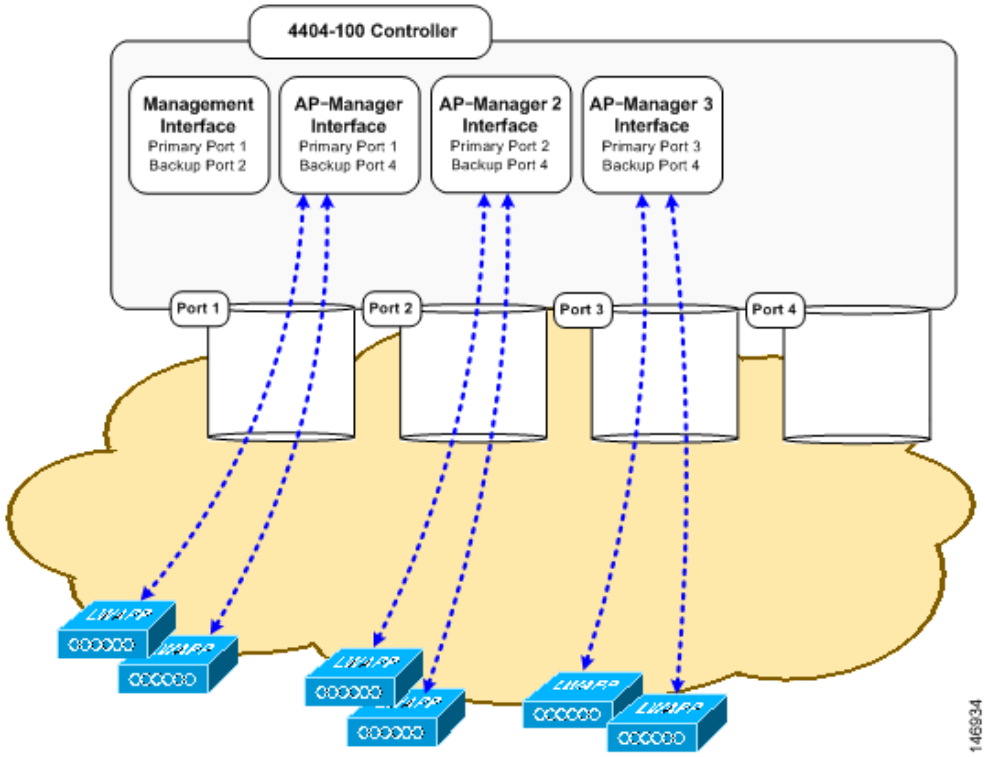
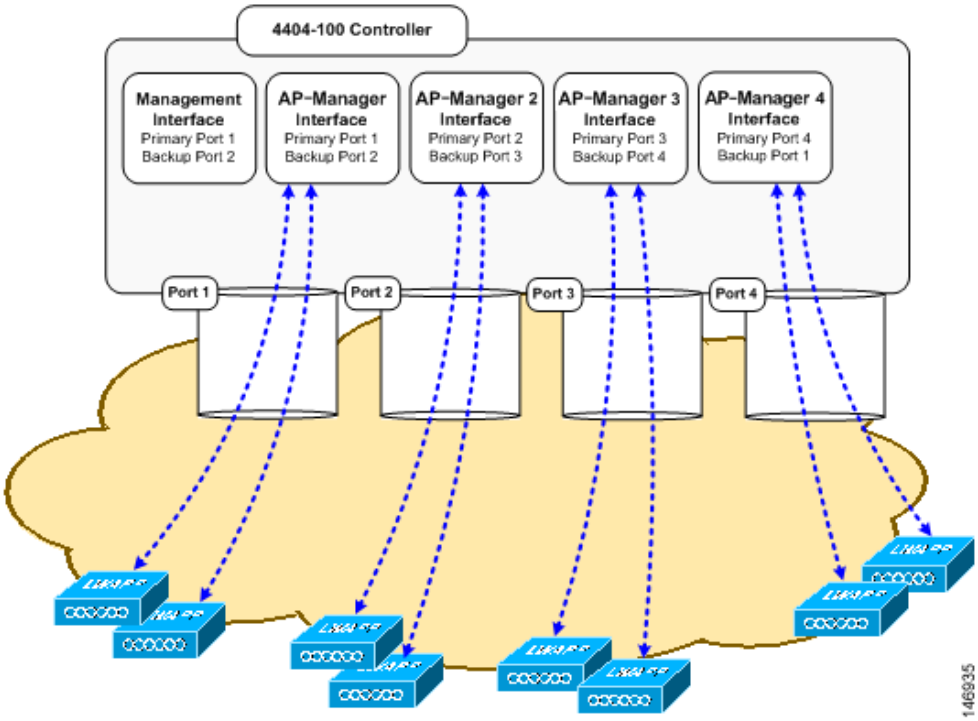


Figure 3-16 illustrates the use of four AP-manager interfaces to support 100 access points. Each has a unique primary port, but each port is also a secondary port for one of the AP-manager interfaces.

Figure 3-16 Four AP-Manager Interfaces



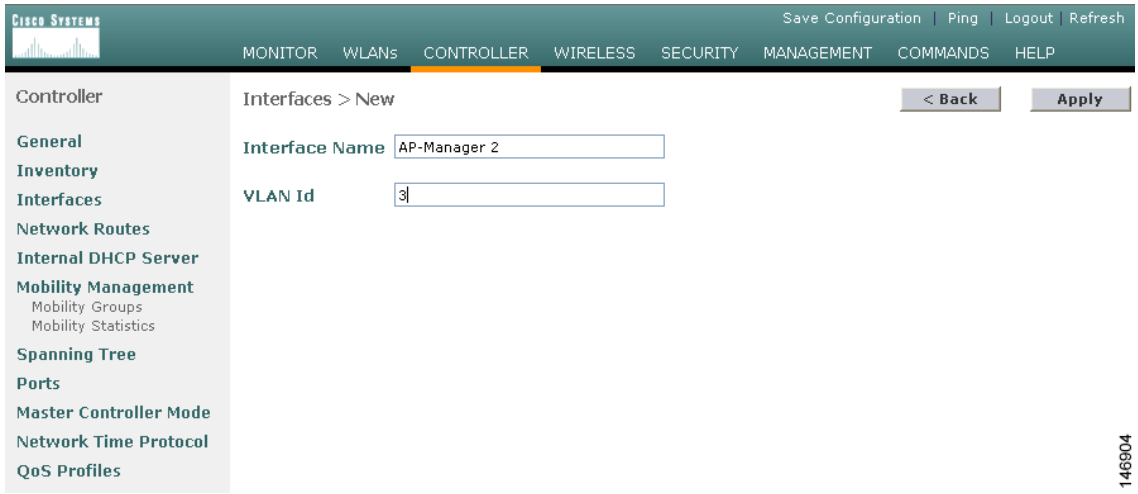
This configuration has the advantage of load-balancing all 100 access points evenly across all four AP-manager interfaces. If one of the AP-manager interfaces fails, all of the access points connected to the controller would be evenly distributed among the three available AP-manager interfaces. For example, if AP-manager interface 2 fails, the remaining AP-manager interfaces (1, 3, and 4) would each manage approximately 33 access points.

Follow these steps to create multiple AP-manager interfaces.

Step 1 Click **Controller** > **Interfaces** to access the Interfaces page.

Step 2 Click **New**. The Interfaces > New page appears (see Figure 3-18).

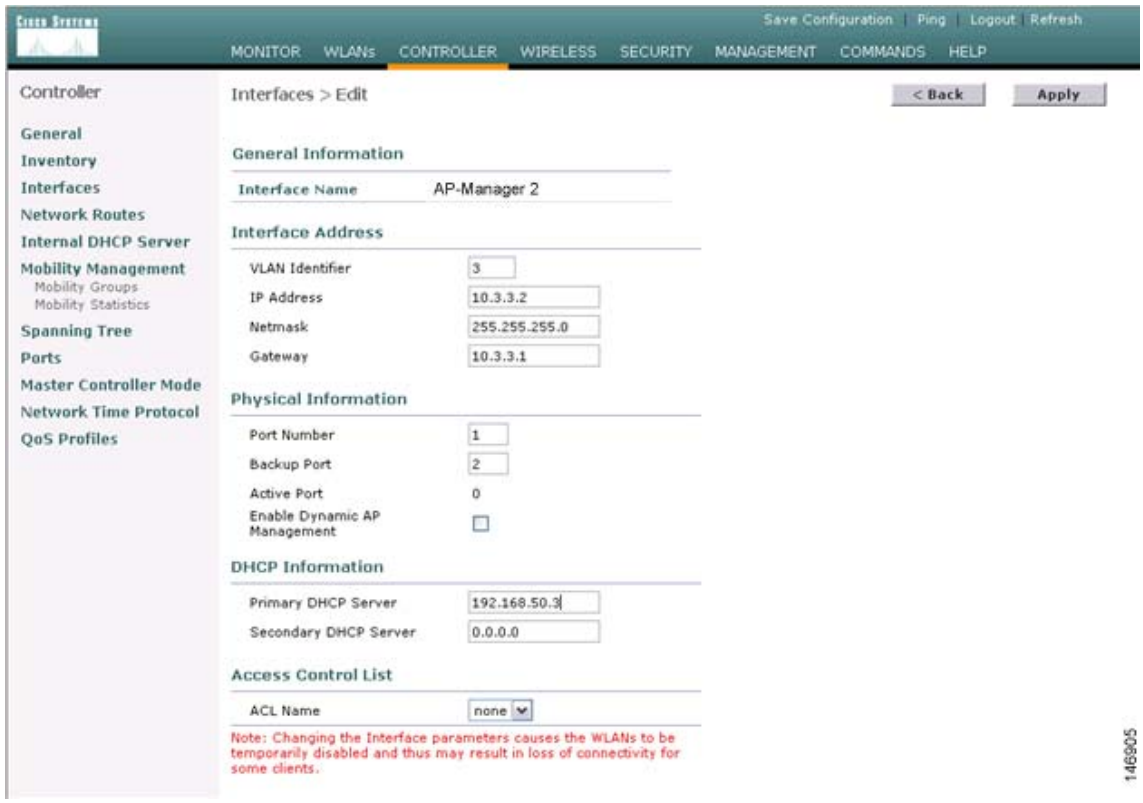
Figure 3-17 Interfaces > New Page



Step 3 Enter an AP-manager interface name and a VLAN identifier, as shown above.

Step 4 Click **Apply** to commit your changes. The Interfaces > Edit page appears (see Figure 3-18).

Figure 3-18 Interfaces > Edit Page



Step 5 Enter the appropriate interface parameters.

Step 6 To make the interface an AP-manager interface, check the **Enable Dynamic AP Management** check box.

Step 7 Click **Save Configuration** to save your settings.

Step 8 Repeat this procedure for each additional AP-manager interface that you want to create.

Connecting Additional Ports

To support more than 48 access points with a 4400 series controller in Layer 2 mode, you must connect more controller ports to individual broadcast domains that are completely separated. Table 3-8 provides an example in which each controller port is connected to an individual switch.

Table 3-8 Example Port Configuration on a 4404 Controller in Layer 2 Mode

[Distribution Switch 1]=Trunk=[Distribution Switch 2]			
dot1q	access	access	access
VLAN 250	VLAN 992	VLAN 993	VLAN 994
port 1	port 2	port 3	port 4

VLANs 992, 993, and 994 (used here as VLAN examples) are access VLANs, and you can assign them any VLAN IDs that you choose. An IP address is not allocated to these VLANs, and these ports are access ports only. To connect additional access points, assign the access port connecting the access point to VLAN 992, 993, or 994. The access point then joins the controller using that isolated VLAN with Layer 2 LWAPP. All Layer 2 LWAPP traffic received on ports 2, 3, and 4 egresses the management port (configured as port 1) on VLAN 250 with a dot1q tag of 250.

With a Layer 2 LWAPP configuration, you should distribute access points across VLANs 250, 992, 993, and 994 manually. Ideally, you should distribute 25 access points per port to balance a total of 100 access points. If you have less than 100 access points, divide the number of access points by 4 and distribute that number. For example, 48 total access points divided by 4 equals 12 access points per 4404 port. You could connect 48 access points to port 1, 48 to port 2, and only 2 to port 3, but this unbalanced distribution does not provide the best throughput performance for wireless clients and is not recommended.

It does not matter where you connect ports 2, 3, and 4 as long as they can communicate with the access points configured for their isolated VLANs. If VLAN 250 is a widely used infrastructure VLAN within your network and you notice network congestion, redistribute all of the access points connected to VLAN 250 to ports 2, 3, and 4. Port 1 still remains connected to VLAN 250 as the management network interface but transports data only from wireless clients proxied by the controller.

Configuring Controller Settings

This chapter describes how to configure settings on the controllers. This chapter contains these sections:

Using the Configuration Wizard

This section describes how to configure basic settings on a controller for the first time or after the configuration has been reset to factory defaults. The contents of this chapter are similar to the instructions in the quick start guide that shipped with your controller.

You use the configuration wizard to configure basic settings. You can run the wizard on the CLI or the GUI. This section explains how to run the wizard on the CLI.

This section contains these sections:

Before You Start

You should collect these basic configuration parameters before configuring the controller:

- System name for the controller
- 802.11 protocols supported: 802.11a and/or 802.11b/g
- Administrator usernames and passwords (optional)
- Distribution System (network) port static IP Address, netmask, and optional default gateway IP Address
- Service port static IP Address and netmask (optional)
- Distribution System physical port (1000BASE-T, 1000BASE-SX, or 10/100BASE-T)

Note Each 1000BASE-SX connector provides a 100/1000 Mbps wired connection to a network through an 850nM (SX) fiber-optic link using an LC physical connector.

- Distribution System port VLAN assignment (optional)
- Distribution System port Web and Secure Web mode settings: enabled or disabled
- Distribution System port Spanning Tree Protocol: enabled/disabled, 802.1D/fast/off mode per port, path cost per port, priority per port, bridge priority, forward delay, hello time, maximum age
- WLAN Configuration: SSID, VLAN assignments, Layer 2 Security settings, Layer 3 Security settings, QoS assignments
- Mobility Settings: Mobility Group Name (optional)
- RADIUS Settings
- SNMP Settings
- NTP server settings (the wizard prompts you for NTP server settings only when you run the wizard on a wireless controller network module installed in a Cisco Integrated Services router)
- Other port and parameter settings: service port, Radio Resource Management (RRM), third-party access points, console port, 802.3x flow control, and system logging

Resetting the Device to Default Settings

If you need to start over during the initial setup process, you can reset the controller to factory default settings.

Note After resetting the configuration to defaults, you need a serial connection to the controller to use the configuration wizard.

Resetting to Default Settings Using the CLI

Follow these steps to reset the configuration to factory default settings using the CLI:

Step 1 Enter **reset system**. At the prompt that asks whether you need to save changes to the configuration, enter **Y** or **N**. The unit reboots.

Step 2 When you are prompted for a username, enter **recover-config** to restore the factory default configuration. The Cisco Wireless LAN Controller reboots and displays this message:

```
Welcome to the Cisco WLAN Solution Wizard Configuration Tool
```

Step 3 Use the configuration wizard to enter configuration settings.

Resetting to Default Settings Using the GUI

Follow these steps to return to default settings using the GUI:

Step 1 Open your Internet browser. The GUI is fully compatible with Microsoft Internet Explorer version 6.0 or later on Windows platforms.

Step 2 Enter the controller IP address in the browser address line and press **Enter**. An Enter Network Password window appears.

Step 3 Enter your username in the User Name field. The default username is *admin*.

Step 4 Enter the wireless device password in the Password field and press **Enter**. The default password is *admin*.

Step 5 Browse to the **Commands/Reset to Factory Defaults** page.

Step 6 Click **Reset**. At the prompt, confirm the reset.

Step 7 Reboot the unit and do not save changes.

Step 8 Use the configuration wizard to enter configuration settings.

Running the Configuration Wizard on the CLI

When the controller boots at factory defaults, the bootup script runs the configuration wizard, which prompts the installer for initial configuration settings. Follow these steps to enter settings using the wizard on the CLI:

Step 1 Connect your computer to the controller using a DB-9 null-modem serial cable.

Step 2 Open a terminal emulator session using these settings:

- 9600 baud
- 8 data bits
- 1 stop bit
- no parity
- no hardware flow control

Step 3 At the prompt, log into the CLI. The default username is *admin* and the default password is *admin*.

Step 4 If necessary, enter **reset system** to reboot the unit and start the wizard.

Step 5 The first wizard prompt is for the system name. Enter up to 32 printable ASCII characters.

Step 6 Enter an administrator username and password, each up to 24 printable ASCII characters.

Step 7 Enter the service-port interface IP configuration protocol: **none** or **DHCP**. If you do not want to use the service port or if you want to assign a static IP Address to the service port, enter **none**.

Step 8 If you entered **none** in step 7 and need to enter a static IP address for the service port, enter the service-port interface IP address and netmask for the next two prompts. If you do not want to use the service port, enter **0.0.0.0** for the IP address and netmask.

Step 9 Enter the management interface IP Address, netmask, default router IP address, and optional VLAN identifier (a valid VLAN identifier, or **0** for untagged).

Step 10 Enter the Network Interface (Distribution System) Physical Port number. For the controller, the possible ports are 1 through 4 for a front panel GigE port.

Step 11 Enter the IP address of the default DHCP Server that will supply IP Addresses to clients, the management interface, and the service port interface if you use one.

Step 12 Enter the LWAPP Transport Mode, **LAYER2** or **LAYER3** (refer to the Layer 2 and Layer 3 LWAPP Operation chapter for an explanation of this setting).

Step 13 Enter the Virtual Gateway IP Address. This address can be any fictitious, unassigned IP address (such as 1.1.1.1) to be used by Layer 3 Security and Mobility managers.

Step 14 Enter the Cisco WLAN Solution Mobility Group (RF group) name.

Step 15 Enter the WLAN 1 SSID, or network name. This is the default SSID that lightweight access points use to associate to a controller.

Step 16 Allow or disallow Static IP Addresses for clients. Enter **yes** to allow clients to supply their own IP addresses. Enter **no** to require clients to request an IP Address from a DHCP server.

Step 17 If you need to configure a RADIUS Server, enter **yes**, and enter the RADIUS server IP address, the communication port, and the shared secret. If you do not need to configure a RADIUS server or you want to configure the server later, enter **no**.

Step 18 Enter a country code for the unit. Enter **help** to list the supported countries.

Note When you run the wizard on a wireless controller network module installed in a Cisco Integrated Services Router, the wizard prompts you for NTP server settings. The controller network module does not have a battery and cannot save a time setting. It must receive a time setting from an NTP server when it powers up.

Step 19 Enable and disable support for 802.11b, 802.11a, and 802.11g.

Step 20 Enable or disable radio resource management (RRM) (auto RF).

When you answer the last prompt, the controller saves the configuration, reboots with your changes, and prompts you to log in or to enter **recover-config** to reset to the factory default configuration and return to the wizard.

Managing the System Time and Date

You can configure the controller to obtain the time and date from an NTP server or you can configure the time and date manually.

Configuring Time and Date Manually

On the CLI, enter **show time** to check the system time and date. If necessary, enter **config time** *mm/dd/yy hh:mm:ss* to set the time and date.

To enable Daylight Saving Time, enter **config time timezone enable**.

Configuring NTP

On the CLI, enter **config time ntp** *server-ip-address* to specify the NTP server for the controller. Enter **config time ntp** *interval* to specify, in seconds, the polling interval.

Configuring a Country Code

Controllers are designed for use in many countries with varying regulatory requirements. You can configure a country code for the controller to ensure that it complies with your country's regulations.

On the CLI, enter **config country** *code* to configure the country code. Enter **show country** to check the configuration.

Note The controller must be installed by a network administrator or qualified IT professional and the proper country code must be selected. Following installation, access to the unit should be password protected by the installer to maintain compliance with regulatory requirements and to ensure proper unit functionality.

Table 4-1 lists commonly used country codes and the 802.11 bands that they allow. For a complete list of country codes supported per product, refer to www.ciscofax.com or http://www.cisco.com/warp/public/779/smbiz/wireless/approvals.html.

Table 4-1 Commonly Used Country Codes

Country Code	Country	802.11 Bands Allowed
US	United States of America	802.11b, 802.11g, and 802.11a low, medium, and high bands
USL	US Low	802.11b, 802.11g, and 802.11a low and medium bands (used for legacy 802.11a interface cards that do not support 802.11a high band)
AU	Australia	802.11b, 802.11g, and 802.11a
AT	Austria	802.11b, 802.11g, and 802.11a
BE	Belgium	802.11b, 802.11g, and 802.11a
CA	Canada	802.11b and 802.11g
DK	Denmark	802.11b, 802.11g, and 802.11a
FI	Finland	802.11b, 802.11g, and 802.11a
FR	France	802.11b, 802.11g, and 802.11a
DE	Germany	802.11b, 802.11g, and 802.11a
GR	Greece	802.11b and 802.11g
IE	Ireland	802.11b, 802.11g, and 802.11a
IN	India	802.11b and 802.11a
IT	Italy	802.11b, 802.11g, and 802.11a
JP	Japan	802.11b, 802.11g, and 802.11a
KR	Republic of Korea	802.11b, 802.11g, and 802.11a
LU	Luxembourg	802.11b, 802.11g, and 802.11a
NL	Netherlands	802.11b, 802.11g, and 802.11a
PT	Portugal	802.11b, 802.11g, and 802.11a
ES	Spain	802.11b, 802.11g, and 802.11a
SE	Sweden	802.11b, 802.11g, and 802.11a
GB	United Kingdom	802.11b, 802.11g, and 802.11a

Enabling and Disabling 802.11 Bands

You can enable or disable the 802.11b/g (2.4-GHz) and the 802.11a (5-GHz) bands for the controller to comply with the regulatory requirements in your country. By default, both 802.11b/g and 802.11a are enabled.

On the CLI, enter **config 80211b disable network** to disable 802.11b/g operation on the controller. Enter **config 80211b enable network** to re-enable 802.11b/g operation.

Enter **config 80211a disable network** to disable 802.11a operation on the controller. Enter **config 80211a enable network** to re-enable 802.11a operation.

Configuring Administrator Usernames and Passwords

You can configure administrator usernames and passwords to prevent unauthorized users from reconfiguring the controller and viewing configuration information.

On the CLI, enter **config mgmtuser add** *username password* **read-write** to create a username-password pair with read-write privileges. Enter **config mgmtuser add** *username password* **read-only** to create a username-password pair with read-only privileges. Usernames and passwords are case-sensitive and can contain up to 24 ASCII characters. Usernames and passwords cannot contain spaces.

To change the password for an existing username, enter **config mgmtuser password** *username new_password*

To list configured users, enter **show mgmtuser**.

Configuring RADIUS Settings

If you need to use a RADIUS server for accounting or authentication, follow these steps on the CLI to configure RADIUS settings for the controller:

Step 1 Enter **config radius acct** *ip-address* to configure a RADIUS server for accounting.

Step 2 Enter **config radius acct** *port* to specify the UDP port for accounting.

Step 3 Enter **config radius acct** *secret* to configure the shared secret.

Step 4 Enter **config radius acct** *enable* to enable accounting. Enter **config radius acct** *disable* to disable accounting. Accounting is disabled by default.

Step 5 Enter **config radius auth** *ip-address* to configure a RADIUS server for authentication.

Step 6 Enter **config radius auth** *port* to specify the UDP port for authentication.

Step 7 Enter **config radius auth** *secret* to configure the shared secret.

Step 8 Enter **config radius auth** *enable* to enable authentication. Enter **config radius acct** *disable* to disable authentication. Authentication is disabled by default.

Step 9 Use the **show radius acct statistics**, **show radius auth statistics**, and **show radius summary** commands to verify that the RADIUS settings are correctly configured.

Configuring SNMP Settings

Cisco recommends that you use the GUI to configure SNMP settings on the controller. To use the CLI, follow these steps:

Step 1 Enter **config snmp community create** *name* to create an SNMP community name.

Step 2 Enter **config snmp community delete** *name* to delete an SNMP community name.

Step 3 Enter **config snmp community accessmode ro** *name* to configure an SNMP community name with read-only privileges. Enter **config snmp community accessmode rw** *name* to configure an SNMP community name with read-write privileges.

Step 4 Enter **config snmp community ipaddr** *ip-address ip-mask name* to configure an IP address and subnet mask for an SNMP community.

Step 5 Enter **config snmp community mode enable** to enable a community name. Enter **config snmp community mode disable** to disable a community name.

Step 6 Enter **config snmp trapreceiver create** *name ip-address* to configure a destination for a trap.

Step 7 Enter **config snmp trapreceiver delete** *name* to delete a trap.

Step 8 Enter **config snmp trapreceiver ipaddr** *old-ip-address name new-ip-address* to change the destination for a trap.

Step 9 Enter **config snmp trapreceiver mode enable** to enable traps. Enter **config snmp trapreceiver mode disable** to disable traps.

Step 10 Enter **config snmp syscontact** *syscontact-name* to configure the name of the SNMP contact. Enter up to 31 alphanumeric characters for the contact name.

Step 11 Enter **config snmp syslocation** *syslocation-name* to configure the SNMP system location. Enter up to 31 alphanumeric characters for the location.

Step 12 Use the **show snmpcommunity** and **show snmptrap** commands to verify that the SNMP traps and communities are correctly configured.

Step 13 Use the **show trapflags** command to see the enabled and disabled trapflags. If necessary, use the **config trapflags** commands to enable or disable trapflags.

Enabling 802.3x Flow Control

802.3x Flow Control is disabled by default. To enable it, enter **config switchconfig flowcontrol enable**.

Enabling System Logging

System logging is disabled by default. Enter **show syslog** to view the current syslog status. Enter **config syslog** to send a controller log to a remote IP Address or hostname.

Enabling Dynamic Transmit Power Control

When you enable Dynamic Transmit Power Control (DTPC), access points add channel and transmit power information to beacons. (On access points that run Cisco IOS software, this feature is called world mode.) Client devices using DTPC receive the information and adjust their settings automatically. For example, a client device used primarily in Japan could rely on DTPC to adjust its channel and power settings automatically when it travels to Italy and joins a network there. DTPC is enabled by default.

Enter this command to disable or enable DTPC:

config {**802.11a** | **802.11bg**} **dtpc** {**enable** | **disable**}

Configuring Multicast Mode

If your network supports packet multicasting you can configure the multicast method that the controller uses. The controller performs multicasting in two modes:

- Unicast mode—In this mode the controller unicasts every multicast packet to every access point associated to the controller. This mode is inefficient but might be required on networks that do not support multicasting.
- Multicast mode—In this mode the controller sends multicast packets to an LWAPP multicast group. This method reduces overhead on the controller processor and shifts the work of packet replication to your network, which is much more efficient than the unicast method.

Understanding Multicast Mode

When you enable multicast mode, the controller does not become a member the multicast group. When the controller receives a multicast packet from the wired LAN, the controller encapsulates the packet using LWAPP and forwards the packet to the LWAPP multicast group address. The controller always uses the management interface for sending multicast packets. Access points in the multicast group receive the packet and forward it to all the BSSIDs mapped to the interface on which clients receive multicast traffic. From the access point perspective, the multicast appears to be a broadcast to all SSIDs.

When the source of the multicast is a wireless client, the multicast packet is unicast to the controller. In this case the controller makes two copies of the packet. One copy is the raw Ethernet packet that the controller sends out to the interface for the wireless LAN on which the client is associated, enabling the receivers on the wired LAN to receive the multicast traffic. The second copy of the packet is LWAPP-encapsulated and is sent to the multicast group. In this case the source of the multicast also receives the multicast packet, which helps the wireless client receive the multicast source.

Guidelines for Using Multicast Mode

Follow these guidelines when you enable multicast mode on your network:

- The Cisco Unified Wireless Network solution uses some IP address ranges for specific purposes, and you should keep these ranges in mind when configuring a multicast group:
  - 224.0.0.0 through 224.0.0.255—Reserved link local addresses
  - 224.0.1.0 through 238.255.255.255—Globally scoped addresses
  - 239.0.0.0 through 239.255.255.255—Limited scope addresses
- When you enable multicast mode on the controller you also must configure an LWAPP multicast group address on the controller. Access points subscribe to the LWAPP multicast group using IGMP.
- Cisco 1100, 1130, 1200, 1230, and 1240 access points use IGMP versions 1, 2, and 3. However, Cisco 1000 series access points use only IGMP v1 to join the multicast group.
- Multicast mode works only in Layer 3 LWAPP mode.
- Access points in monitor mode, sniffer mode, or rogue detector mode do not join the LWAPP multicast group address.

- When using Multiple controllers on the network, make sure that the same multicast address is configured on all the controllers.
- Multicast mode does not work across intersubnet mobility events such as guest tunneling, site-specific VLANs, or interface override using RADIUS. However, multicast mode does work in these subnet mobility events when you disable the layer 2 IGMP snooping/CGMP features on the wired LAN.
- The controller drops any multicast packets sent to the UDP port numbers 12222, 12223, and 12224. Make sure the multicast applications on your network do not use those port numbers.

Enabling Multicast Mode

Multicasting is disabled by default. Use the commands in Table 4-2 to configure multicast mode on the controller CLI.

Table 4-2 CLI Commands for Configuring Multicast Mode

Command	Multicast Mode
config network multicast global {**enable** | **disable**}	Enable or disable multicasting
config network multicast mode unicast	Configure the controller to use the unicast method to send multicast packets
config network multicast mode multicast *multicast-group-ip-address*	Configure the controller to use the multicast method to send multicast packets to an LWAPP multicast group.

You can also enable multicast mode on the Configure > Switch IP System General page on the WCS interface.

Configuring the Supervisor 720 to Support the WiSM

When you install a WiSM in a Cisco Catalyst 6500 switch, you must configure the Supervisor 720 to support the WiSM. When the supervisor detects the WiSM, the supervisor creates 10 GigabitEthernet interfaces, ranging from Gig*slot*/1 to Gig*slot*/8. For example, if the WiSM is in slot 9, the supervisor creates interfaces Gig9/1 through Gig9/8. The first eight GigabitEthernet interfaces must be organized into two etherchannel bundles of four interfaces each. The remaining two GigabitEthernet interfaces are used as service-port interfaces, one for each controller on the WiSM. You must manually create VLANs to communicate with the ports on the WiSM.

Note The WiSM is also supported on Cisco 7600 Series Routers running only Cisco IOS Release 12.2(18)SXF5.

General WiSM Guidelines

Keep these general guidelines in mind when you add a WiSM to your network:

- The switch ports leading to the controller service port are automatically configured and cannot be manually configured.
- The switch ports leading to the controller data ports should be configured as edge ports to avoid sending unnecessary BPDUs.
- The switch ports leading to the controller data ports should not be configured with any additional settings (such as port channel or SPAN destination) other than settings necessary for carrying data traffic to and from the controllers.
- The WiSM controllers support Layer 3 LWAPP mode, but they do not support Layer 2 LWAPP mode.

Note Refer to Chapter 3 for information on configuring the WiSM's ports and interfaces.

Configuring the Supervisor

Log into the switch CLI and, beginning in Privileged Exec mode, follow these steps to configure the supervisor to support the WiSM:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**interface** *vlan*	Create a VLAN to communicate with the data ports on the WiSM and enter interface config mode.
Step 3	**ip address** *ip-address gateway*	Assign an IP address and gateway to the VLAN.
Step 4	**ip helper-address** *ip-address*	Assign a helper address to the VLAN.
Step 5	**end**	Return to global config mode.
Step 6	**interface port-channel 1**	Configure a port-channel to bundle the automatically created Gigabit interfaces 1-4 into an etherchannel.
	a. **switchport trunk encapsulation dot1q**	Configure the previously created port-channel interfaces as trunk ports. For the native VLAN on the ports, configure the VLAN that you created for communicating with the WiSM data ports.
	b. **switchport trunk native vlan** *vlan*	
	c. **switchport mode trunk**	
	d. **end**	Return to global config mode.

	Command	Purpose
Step 7	**interface port-channel 2**	Configure a port-channel to bundle the automatically created Gigabit interfaces 5-8 into an etherchannel.
	a. **switchport trunk encapsulation dot1q**	Configure the second port-channel as the first.
	b. **switchport trunk native vlan** *vlan*	
	c. **switchport mode trunk**	
	d. **end**	Return to global config mode.
Step 8	**interface GigabitEthernet9/1-4**	Establish a separate Gigabit etherchannel for the first controller on the WiSM. For the native VLAN on the ports, configure the VLAN that you created for communicating with the WiSM data ports.
	a. **switchport trunk encapsulation dot1q**	Configure the previously created port-channel interfaces as trunk ports. For the native VLAN on the ports, configure the VLAN that you created for communicating with the WiSM data ports.
	b. **switchport trunk native vlan** *vlan*	
	c. **switchport mode trunk**	
	d. **channel-group 1 mode on**	Bind the physical GigabitEthernet interfaces to the logical port-channel interface.
Step 9	**interface GigabitEthernet9/5-8**	Establish a separate Gigabit etherchannel for the second controller on the WiSM. For the native VLAN on the ports, configure the VLAN that you created for communicating with the WiSM data ports.
	a. **switchport trunk encapsulation dot1q**	Configure the second group of GigabitEthernet interfaces as the first.
	b. **switchport trunk native vlan** *vlan*	
	c. **switchport mode trunk**	
	d. **channel-group 2 mode on**	Bind the physical GigabitEthernet interfaces to the logical port-channel interface.
Step 10	**interface** *vlan*	Create a VLAN to communicate with the service ports on the WiSM.
Step 11	**ip address** *ip-address gateway*	Assign an IP address and gateway to the VLAN.
Step 12	**end**	Return to global config mode.
Step 13	**wism service-vlan** *vlan*	Configure the VLAN that you created in step 10 to communicate with the WiSM service ports.
Step 14	**end**	Return to global config mode.
Step 15	**show wism status**	Verify that the WiSM is operational.

Using the Wireless LAN Controller Network Module

Keep these guidelines in mind when using a wireless LAN controller network module (CNM) installed in a Cisco Integrated Services Router:

- The controller network module does not support IPSec. To use IPSec with the CNM, configure IPSec on the router in which the CNM is installed. Click this link to browse to IPSec configuration instructions for routers:

  http://www.cisco.com/en/US/tech/tk583/tk372/tech_configuration_guides_list.html

- The controller network module does not have a battery and cannot save a time setting. It must receive a time setting from an NTP server when it powers up. When you install the module the configuration wizard prompts you for NTP server information.

- To access the CNM bootloader, Cisco recommends that you reset the CNM from the router. If you reset the CNM from a CNM user interface the router might reset the CNM while you are using the bootloader.

  When you reset the CNM from a CNM interface you have 17 minutes to use the bootloader before the router automatically resets the CNM. The CNM bootloader does not run the Router Blade Configuration Protocol (RBCP), so the RBCP heartbeat running on the router times out after 17 minutes, triggering a reset of the CNM.

  If you reset the CNM from the router, the router stops the RBCP heartbeat exchange and does not restart it until the CNM boots up. To reset the CNM from the router, enter this command on the router CLI:

  service-module wlan-controller 1/0 reset

Configuring Security Solutions

This chapter describes security solutions for wireless LANs. This chapter contains these sections:

Cisco WLAN Solution Security

Cisco WLAN Solution Security includes the following sections:

Security Overview

The Cisco WLAN Solution Security solution bundles potentially complicated Layer 1, Layer 2, and Layer 3 802.11 Access Point security components into a simple policy manager that customizes system-wide security policies on a per-WLAN basis. The Cisco WLAN Solution Security solution provides simple, unified, and systematic security management tools.

One of the biggest hurdles to WLAN deployment in the enterprise is WEP encryption, which is weak standalone encryption method. A newer problem is the availability of low-cost access points, which can be connected to the enterprise network and used to mount man-in-the-middle and denial-of-service attacks. Also, the complexity of add-on security solutions has prevented many IT managers from embracing the benefits of the latest advances in WLAN security.

Layer 1 Solutions

The Cisco WLAN Solution Operating System Security solution ensures that all clients gain access within an operator-set number of attempts. Should a client fail to gain access within that limit, it is automatically excluded (blocked from access) until the operator-set timer expires. The Operating System can also disable SSID broadcasts on a per-WLAN basis.

Layer 2 Solutions

If a higher level of security and encryption is required, the network administrator can also implement industry-standard security solutions, such as: 802.1X dynamic keys with EAP (extensible authentication protocol), or WPA (Wi-Fi protected access) dynamic keys. The Cisco WLAN Solution WPA implementation includes AES (advanced encryption standard), TKIP + Michael (temporal key integrity protocol + message integrity code checksum) dynamic keys, or WEP (Wired Equivalent Privacy) static keys. Disabling is also used to automatically block Layer 2 access after an operator-set number of failed authentication attempts.

Regardless of the wireless security solution selected, all Layer 2 wired communications between Cisco Wireless LAN Controllers and Cisco 1000 Series lightweight access points are secured by passing data through LWAPP tunnels.

Layer 3 Solutions

The WEP problem can be further solved using industry-standard Layer 3 security solutions, such as VPNs (virtual private networks), L2TP (Layer Two Tunneling Protocol), and IPSec (IP security) protocols. The Cisco WLAN Solution L2TP implementation includes IPSec, and the IPSec implementation includes IKE (internet key exchange), DH (Diffie-Hellman) groups, and three optional levels of encryption: DES (ANSI X.3.92 data encryption standard), 3DES (ANSI X9.52-1998 data encryption standard), or AES/CBC (advanced encryption standard/cipher block chaining). Disabling is also used to automatically block Layer 3 access after an operator-set number of failed authentication attempts.

The Cisco WLAN Solution IPSec implementation also includes industry-standard authentication using: MD5 (message digest algorithm), or SHA-1 (secure hash algorithm-1).

The Cisco WLAN Solution supports local and RADIUS MAC (media access control) filtering. This filtering is best suited to smaller client groups with a known list of 802.11 access card MAC addresses.

Finally, the Cisco WLAN Solution supports local and RADIUS user/password authentication. This authentication is best suited to small to medium client groups.

Rogue Access Point Solutions

This section describes security solutions for rogue access points.

Rogue Access Point Challenges

Rogue access points can disrupt WLAN operations by hijacking legitimate clients and using plaintext or other denial-of-service or man-in-the-middle attacks. That is, a hacker can use a rogue access point to capture sensitive information, such as passwords and username. The hacker can then transmit a series of clear-to-send (CTS) frames, which mimics an access point informing a particular NIC to transmit and instructing all others to wait, which results in legitimate clients being unable to access the WLAN resources. WLAN service providers thus have a strong interest in banning rogue access points from the air space.

The Operating System Security solution uses the Radio Resource Management (RRM) function to continuously monitor all nearby access points, automatically discover rogue access points, and locate them as described in the "Tagging and Containing Rogue Access Points" section on page 5-3.

Tagging and Containing Rogue Access Points

When the Cisco WLAN Solution is monitored using WCS, WCS generates the flags as rogue access point traps, and displays the known rogue access points by MAC address. The operator can then display a map showing the location of the Cisco 1000 Series lightweight access points closest to each rogue access point, allowing Known or Acknowledged rogue access points (no further action), marking them as Alert rogue access points (watch for and notify when active), or marking them as contained rogue access points. Between one and four Cisco 1000 Series lightweight access points discourage rogue access point clients by sending the clients deauthenticate and disassociate messages whenever they associate with the rogue access point.

When the Cisco WLAN Solution is monitored using a GUI or a CLI, the interface displays the known rogue access points by MAC address. The operator then has the option of marking them as Known or Acknowledged rogue access points (no further action), marking them as Alert rogue access points (watch

for and notify when active), or marking them as Contained rogue access points (have between one and four Cisco 1000 Series lightweight access points discourage rogue access point clients by sending the clients deauthenticate and disassociate messages whenever they associate with the rogue access point).

Integrated Security Solutions

- Cisco WLAN Solution Operating System Security is built around a robust 802.1X AAA (authorization, authentication and accounting) engine, which allows operators to rapidly configure and enforce a variety of security policies across the Cisco WLAN Solution.
- The controllers and lightweight access points are equipped with system-wide authentication and authorization protocols across all ports and interfaces, maximizing system security.
- Operating System Security policies are assigned to individual WLANs, and lightweight access points simultaneously broadcast all (up to 16) configured WLANs. This can eliminate the need for additional access points, which can increase interference and degrade system throughput.
- The controllers securely terminates IPSec VPN clients, which can reduce the load on centralized VPN concentrators.
- Operating System Security uses the RRM function to continually monitor the air space for interference and security breaches, and notify the operator when they are detected.
- Operating System Security works with industry-standard authorization, authentication, and accounting (AAA) servers, making system integration simple and easy.
- The Operating System Security solution offers comprehensive Layer 2 and Layer 3 encryption algorithms which typically require a large amount of processing power. Rather than assigning the encryption tasks to yet another server, the controller can be equipped with a VPN/Enhanced Security Module that provides extra hardware required for the most demanding security configurations.

Configuring the System for SpectraLink NetLink Telephones

For best integration with the Cisco Wireless LAN Solution, SpectraLink NetLink Telephones require an extra Operating System configuration step: enable long preambles. The radio preamble (sometimes called a header) is a section of data at the head of a packet that contains information that wireless devices need when sending and receiving packets. Short preambles improve throughput performance, so they are enabled by default. However, some wireless devices, such as SpectraLink NetLink phones, require long preambles.

Use one of these methods to enable long preambles:

- Using the GUI to Enable Long Preambles, page 5-5
- Using the CLI to Enable Long Preambles, page 5-5

Using the GUI to Enable Long Preambles

Use this procedure to use the GUI to enable long preambles to optimize the operation of SpectraLink NetLink phones on your wireless LAN.

Step 1 Log into the controller GUI.

Step 2 Follow this path to navigate to the 802.11b/g Global Parameters page:

Wireless > Global RF > 802.11b/g Network

If the Short Preamble Enabled box is checked, continue with this procedure. However, if the Short Preamble Enabled box is unchecked (which means that long preambles are enabled), the controller is already optimized for SpectraLink NetLink phones and you do not need to continue this procedure.

Step 3 Uncheck the Short Preamble Enabled check box to enable long preambles.

Step 4 Click **Apply** to update the controller configuration.

Note If you do not already have an active CLI session to the controller, Cisco recommends that you start a CLI session to reboot the controller and watch the reboot process. A CLI session is also useful because the GUI loses its connection when the controller reboots.

Step 5 Reboot the controller using Commands > Reboot > Reboot. Click **OK** in response to this prompt:

```
Configuration will be saved and switch will be rebooted. Click ok to confirm.
```

The controller reboots.

Step 6 Log back into the controller GUI and verify that the controller is properly configured. Follow this path to navigate to the 802.11b/g Global Parameters page:

Wireless > Global RF > 802.11b/g Network

If the Short Preamble Enabled box is unchecked, the controller is optimized for SpectraLink NetLink phones.

Using the CLI to Enable Long Preambles

Use this procedure to use the CLI to enable long preambles to optimize the operation of SpectraLink NetLink phones on your wireless LAN.

Step 1 Log into the controller CLI.

Step 2 Enter **show 802.11b** and check the Short preamble mandatory parameter. If the parameter indicates that short preambles are enabled, continue with this procedure. This example shows that short preambles are enabled:

```
Short Preamble mandatory..................... Enabled
```

However, if the parameter shows that short preambles are disabled (which means that long preambles are enabled), the controller is already optimized for SpectraLink NetLink phones and you do not need to continue this procedure. This example shows that short preambles are disabled:

```
Short Preamble mandatory..................... Disabled
```

Step 3 Enter **config 802.11b disable network** to disable the 802.11b/g network. (You cannot enable long preambles on the 802.11a network.)

Step 4 Enter **config 802.11b preamble long** to enable long preambles.

Step 5 Enter **config 802.11b enable network** to re-enable the 802.11b/g network.

Step 6 Enter **reset system** to reboot the controller. Enter **y** when this prompt appears:

```
The system has unsaved changes. Would you like to save them now? (y/n)
```

The controller reboots.

Step 7 To verify that the controller is properly configured, log back into the CLI and enter **show 802.11b** to view these parameters:

```
802.11b Network.............................. Enabled
Short Preamble mandatory..................... Disabled
```

These parameters show that the 802.11b/g network is enabled and that short preambles are disabled.

Using Management over Wireless

The Cisco WLAN Solution Management over Wireless feature allows Cisco WLAN Solution operators to monitor and configure local controllers using a wireless client. This feature is supported for all management tasks except uploads to and downloads from (transfers to and from) the controller.

Before you can use the Management over Wireless feature, you must properly configure the controller using one of these sections:

- Using the GUI to Enable Management over Wireless, page 5-6
- Using the CLI to Enable Management over Wireless, page 5-7

Using the GUI to Enable Management over Wireless

Step 1 In the Web User Interface, use the **Management/Mgmt Via Wireless** links to navigate to the **Management Via Wireless** page.

Step 2 In the **Management Via Wireless** page, verify that the **Enable Controller Management to be accessible from Wireless Clients** selection box is checked. If the selection box is not checked, continue with Step 2. Otherwise, continue with Step 3.

Step 3 In the **Management Via Wireless** page, check the **Enable Controller Management to be accessible from Wireless Clients** selection box to select Management over Wireless for the WLAN.

Step 4 Click **Apply** to enable Management over Wireless for the WLAN.

Step 5 Use a wireless client web browser to connect to the Cisco Wireless LAN Controller Management Port or DS Port IP Address, and log into the Web User Interface to verify that you can manage the WLAN using a wireless client.

Using the CLI to Enable Management over Wireless

Step 1 In the CLI, use the **show network** command to verify whether the Mgmt Via Wireless Interface is Enabled or Disabled. If Mgmt Via Wireless Interface is Disabled, continue with Step 2. Otherwise, continue with Step 3.

Step 2 To Enable Management over Wireless, enter **config network mgmt-via-wireless enable**.

Step 3 Use a wireless client to associate with an access point connected to the controller that you want to manage.

Step 4 Enter **telnet controller-ip-address** and log into the CLI to verify that you can manage the WLAN using a wireless client.

Configuring DHCP

Follow the steps in one of these sections to configure your wireless LAN to use a DHCP server:

- Using the GUI to Configure DHCP, page 5-7
- Using the CLI to Configure DHCP, page 5-8

Using the GUI to Configure DHCP

Follow these steps to use the GUI to configure DHCP.

Step 1 In the Web User Interface, navigate to the **WLANs** page.

Step 2 Locate the WLAN which you wish to configure for a DHCP server, and click the associated **Edit** link to display the **WLANs > Edit** page.

Step 3 Under **General Policies**, check the **DHCP Relay/DHCP Server IP Addr** to verify whether you have a valid DHCP server assigned to the WLAN. If you have no DHCP server assigned to the WLAN, continue with Step 4. Otherwise, continue with Step 9.

Step 4 Under **General Policies**, deselect the **Admin Status Enabled** box.

Step 5 Click **Apply** to disable the WLAN.

Step 6 In the **DHCP Relay/DHCP Server IP Addr** box, enter a valid DHCP server IP Address for this WLAN.

Step 7 Under **General Policies**, select the **Admin Status Enabled** box.

Step 8 Click **Apply** to assign the DHCP server to the WLAN and to enable the WLAN. You are returned to the **WLANs** page.

Step 9 In the upper-right corner of the **WLANs** page, click **Ping** and enter the DHCP server IP Address to verify that the WLAN can communicate with the DHCP server.

Using the CLI to Configure DHCP

Follow these steps to use the CLI to configure DHCP.

Step 1 In the CLI, enter **show wlan** to verify whether you have a valid DHCP server assigned to the WLAN. If you have no DHCP server assigned to the WLAN, continue with Step 2. Otherwise, continue with Step 4.

Step 2 If necessary, use these commands:

- **config wlan disable** *wlan-id*
- **config wlan** dhcp_server *wlan-id dhcp-ip-address*
- **config wlan enable** *wlan-id*

In these commands, *wlan-id* = 1 through 16 and *dhcp-ip-address* = DHCP server IP Address.

Step 3 Enter **show wlan** to verify that you have a DHCP server assigned to the WLAN.

Step 4 Enter **ping** *dhcp-ip-address* to verify that the WLAN can communicate with the DHCP server.

Customizing the Web Authentication Login Screen

Web authentication is a Layer 3 security feature that causes the controller to not allow IP traffic (except DHCP-related packets) from a particular client until that client has correctly supplied a valid username and password. When you use web authentication to authenticate clients, you must define usernames and passwords for each client, and when clients attempt to join the wireless LAN, they must enter a valid username and password when prompted by a login window. These sections describe the default web authentication operation and how to customize the Web Authentication Login window.

- Default Web Authentication Operation, page 5-9
- Customizing Web Authentication Operation, page 5-11
- Example: Sample Customized Web Authentication Login Window, page 5-15

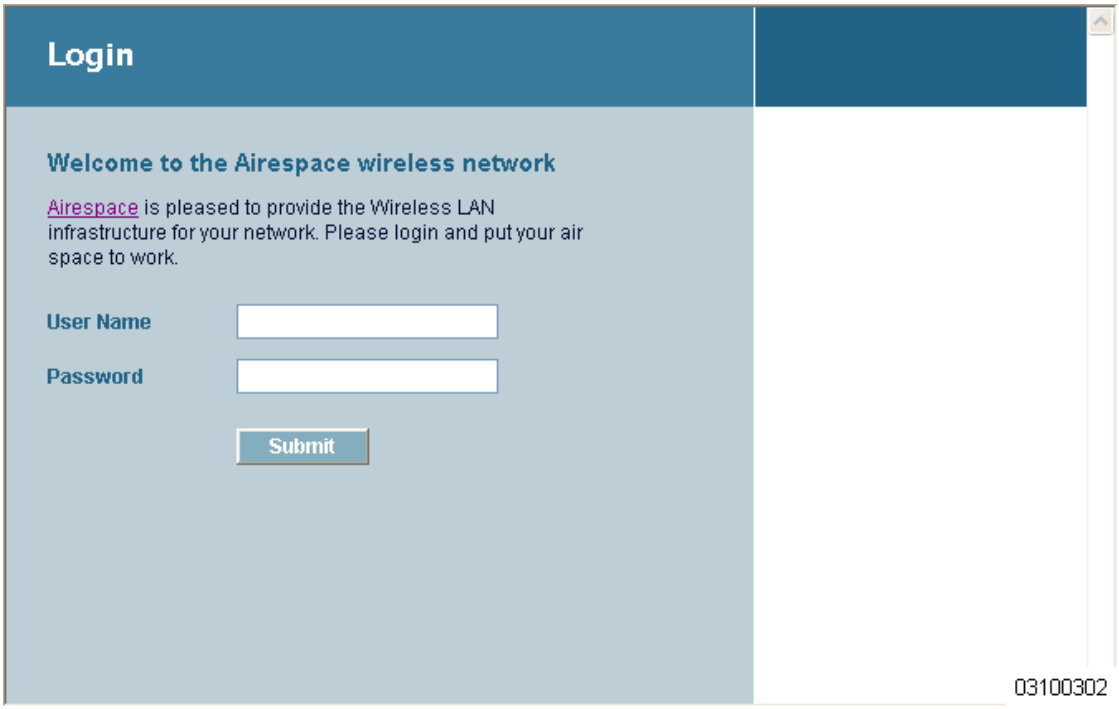
Default Web Authentication Operation

When web authentication is enabled, clients might receive a web-browser security alert the first time that they attempt to access a URL. Figure 5-1 shows a typical security alert.

Figure 5-1 Typical Web-Browser Security Alert

After the client user clicks **Yes** to proceed (or if the client's browser does not display a security alert) the web authentication system redirects the client to a login window. Figure 5-2 shows a typical default Web Authentication Login window.

Figure 5-2 Typical Web Authentication Login Window



The client must respond with a username and password that you define using the Local Net Users > New Web User page, or using the **config netuser add** CLI command.

The default Web Authentication Login window contains Cisco WLAN Solution-specific text and a logo in four customizable areas:

- The Cisco WLAN Solution logo in the upper-right corner can be hidden.
- The window title, “Welcome to the Cisco WLAN Solution OmniAccess wireless network.”
- The message “Cisco WLAN SolutionOmniAccess is pleased to provide the Wireless LAN infrastructure for your network. Please login and put your air space to work.”
- A blank area on the right side of the screen for a logo or other graphic.

The “Customizing Web Authentication Operation” section explains how to customize the Cisco WLAN Solution logo, window title, message, and logo.

When the client enters a valid username and password, the web authentication system displays a successful login window and redirects the authenticated client to the requested URL. Figure 5-3 shows a typical successful login window.

Figure 5-3 Typical Successful Login Window

The default login successful window contains a pointer to a virtual gateway address URL, redirect https://1.1.1.1/logout.html. You define this redirect through the Virtual Gateway IP Address parameter in the configuration wizard, the Virtual Gateway Address parameter on the Interfaces GUI page, or by entering the **config interface create** command in the CLI.

Customizing Web Authentication Operation

This section explains how to customize web authentication operation using the controller CLI. These sections describe the customization tasks:

- Hiding and Restoring the Cisco WLAN Solution Logo, page 5-11
- Changing the Web Authentication Login Window Title, page 5-11
- Changing the Web Message, page 5-12
- Changing the Logo, page 5-12
- Creating a Custom URL Redirect, page 5-14
- Verifying Web Authentication Changes, page 5-14

Hiding and Restoring the Cisco WLAN Solution Logo

Use this command to delete or restore the Cisco WLAN Solution logo:

config custom-web weblogo {**disable** | **enable**}

Changing the Web Authentication Login Window Title

Use this command to change the Web Authentication Login window title:

config custom-web webtitle *title*

Use this command to reset the Web Authentication Login window title back to the default setting:

clear webtitle

Changing the Web Message

Use this command to change the Web Authentication Login window message:

config custom-web webmessage *message*

To reset the Web Authentication Login window message to the Cisco WLAN Solution default ("Cisco WLAN Solution is pleased to provide the Wireless LAN infrastructure for your network. Please login and put your air space to work"), use this command:

clear webmessage

Changing the Logo

These sections explain how to change the logo on the right side of the Web Authentication Login window:

- Preparing the TFTP Server, page 5-12
- Copying the Logo or Graphic to the TFTP Server, page 5-12
- Downloading the Logo or Graphic, page 5-13
- Hiding the Logo, page 5-13

Preparing the TFTP Server

Follow these steps to prepare a TFTP server to load the logo:

Step 1 Make sure you have a TFTP server available to load the logo.

- If you are downloading through the Service port, the TFTP server MUST be on the same subnet as the Service port, because the Service port is not routable.
- If you are downloading through the DS (Distribution System) network port, the TFTP server can be on the same or a different subnet, because the DS port is routable.

Step 2 On the CLI, enter **ping ip-address** to ensure that the controller can contact the TFTP server.

Note The TFTP server cannot run on the same computer as WCS. WCS and the TFTP server use the same communication port.

Copying the Logo or Graphic to the TFTP Server

Follow these steps to copy the logo to the TFTP server:

Step 1 Create a logo in .JPG, .GIF, or .PNG format with a maximum file size of 30 kilobits. For the best fit in the space available, make the logo around 180 pixels wide and 360 pixels high.

Step 2 Make sure the image filename does not contain spaces.

Step 3 Copy the image file to the default directory on your TFTP server.

Downloading the Logo or Graphic

Follow these steps to download the image file to the controller:

Step 1 On the CLI, enter **transfer download start** and answer **n** to the prompt to view the current download settings:

```
transfer download start
Mode..................................... TFTP
Data Type................................ Code
TFTP Server IP........................... xxx.xxx.xxx.xxx
TFTP Path................................ <directory path>
TFTP Filename............................ <filename.jpg|.gif|.png>
Are you sure you want to start? (y/n) n
Transfer Canceled
>
```

Step 2 Use these commands to change the download settings:

transfer download mode tftp

transfer download datatype image

transfer download serverip *tftp-server-ip-address*

transfer download filename {*filename.gif* | *filename.jpg* | *filename.png*}

transfer download path *absolute-tftp-server-path-to-file*

Note Some TFTP servers require only a forward slash (/) as the TFTP server IP address, and the TFTP server automatically determines the path to the correct directory.

Step 3 Enter **transfer download start** to view the updated settings, and answer **y** to the prompt to confirm the current download settings and start the download:

```
transfer download start
Mode..................................... TFTP
Data Type................................ Login Image
TFTP Server IP........................... xxx.xxx.xxx.xxx
TFTP Path................................ <directory path>
TFTP Filename............................ <filename.jpg|.gif|.png>
This may take some time.
Are you sure you want to start? (y/n) y
TFTP Image transfer starting.
Image installed.
```

Hiding the Logo

To remove the logo from the Web Authentication Login window, enter **clear webimage**.

Creating a Custom URL Redirect

Use this command to redirect all web authentication clients to a specific URL (including http:// or https://) after they authenticate:

config custom-web redirecturl *url*

For example, if you want to redirect all clients to www.AcompanyBC.com, use this command:

config custom-web redirecturl www.AcompanyBC.com

To change the redirect back to the default setting, enter **clear redirect-url**.

Verifying Web Authentication Changes

Enter **show custom-web** to verify your web authentication operation changes. This example shows the output from the command when the web authentication settings are at defaults:

```
>show custom-web
Cisco Logo.............................. Enabled
CustomLogo.............................. Disabled
Custom Title............................ Disabled
Custom Message.......................... Disabled
Custom Redirect URL..................... Disabled
External Web Authentication Mode........ Disabled
External Web Authentication URL......... Disabled
```

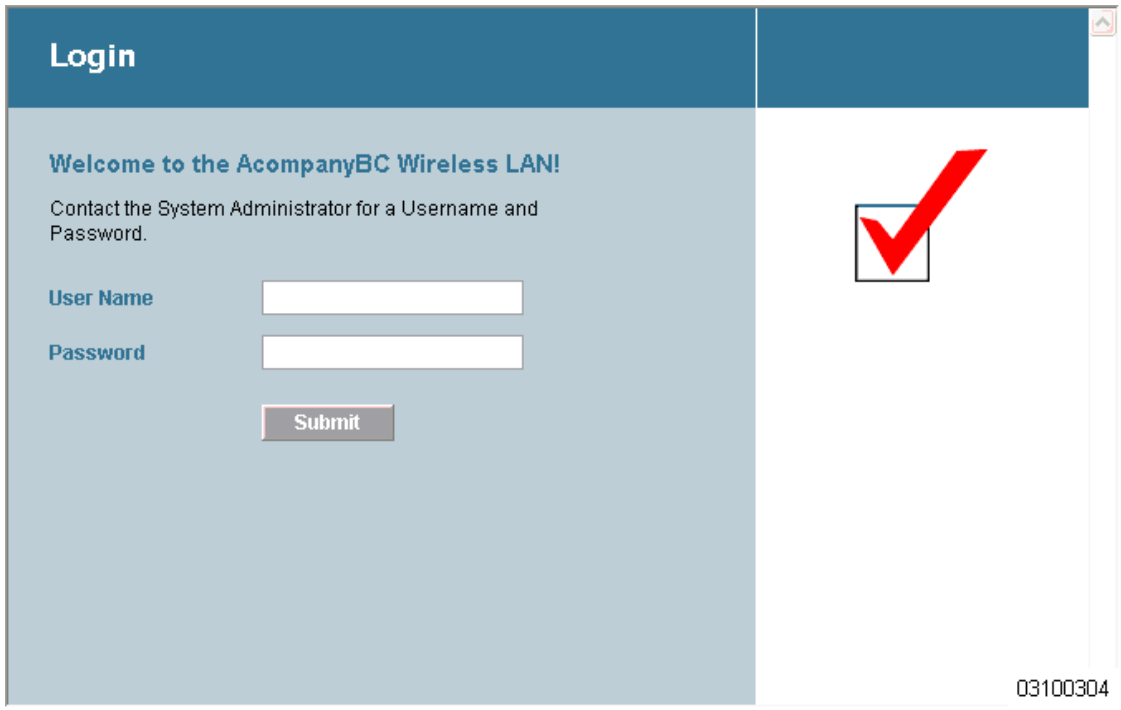
This example shows the output from the command when the web authentication settings have been modified:

```
>show custom-web
Cisco Logo.............................. Disabled
CustomLogo.............................. 00_logo.gif
Custom Title............................ Welcome to the AcompanyBC Wireless LAN!
Custom Message.......................... Contact the System Administrator for a
Username and Password.
Custom Redirect URL..................... http://www.AcompanyBC.com
External Web Authentication Mode........ Disabled
External Web Authentication URL......... Disabled
```

Example: Sample Customized Web Authentication Login Window

Figure 5-4 shows a customized Web Authentication Login window and the CLI commands used to create it.

Figure 5-4 Example of a Customized Web Authentication Login Window



These are the CLI commands used to create the window in Figure 5-4:

```
>config custom-web weblogo disable
>config custom-web webtitle Welcome to the AcompanyBC Wireless LAN!
>config custom-web webmessage Contact the System Administrator for a Username and
Password.
>transfer download start
Mode..................................... TFTP
Data Type................................ Login Image
TFTP Server IP........................... xxx.xxx.xxx.xxx
TFTP Path................................ /
TFTP Filename............................ Logo.gif
This may take some time.
Are you sure you want to start? (y/n) y
TFTP Image transfer starting.
Image installed.
>config custom-web redirecturl http://www.AcompanyBC.com
>show custom-web
Cisco Logo.............................. Disabled
CustomLogo............................... 00_logo.gif
Custom Title............................. Welcome to the AcompanyBC Wireless LAN!
Custom Message........................... Contact the System Administrator for a
Username and Password.
Custom Redirect URL...................... http://www.AcompanyBC.com
External Web Authentication Mode......... Disabled
External Web Authentication URL.......... Disabled
```

Configuring Identity Networking

These sections explain the Identity Networking feature, how it is configured, and the expected behavior for various security policies:

Identity Networking Overview

In most wireless LAN systems, each WLAN has a static policy that applies to all clients associated with an SSID. Although powerful, this method has limitations since it requires clients to associate with different SSIDs to inherit different QoS and security policies.

However, the Cisco Wireless LAN Solution supports Identity Networking, which allows the network to advertise a single SSID but allows specific users to inherit different QoS or security policies based on their user profiles. The specific policies that you can control using identity networking include:

- Quality of Service. When present in a RADIUS Access Accept, the QoS-Level value overrides the QoS value specified in the WLAN profile.
- ACL. When the ACL attribute is present in the RADIUS Access Accept, the system applies the ACL-Name to the client station after it authenticates. This overrides any ACLs that are assigned to the interface.
- VLAN. When a VLAN Interface-Name or VLAN-Tag is present in a RADIUS Access Accept, the system places the client on a specific interface.

Note The VLAN feature only supports MAC filtering, 802.1X, and WPA. The VLAN feature does not support Web Auth or IPSec.

- Tunnel Attributes.

Note When any of the other RADIUS attributes in this section are returned, the Tunnel Attributes must also be returned.

In order for this feature to be enabled, on a per WLAN basis, the Enable AAA Override configuration flag must be enabled.

The Operating System's local MAC Filter database has been extended to include the interface name, allowing local MAC filters to specify to which interface the client should be assigned. A separate RADIUS server can also be used, but the RADIUS server must be defined using the Security menus.

RADIUS Attributes Used in Identity Networking

This section explains the RADIUS attributes used in Identity Networking.

QoS-Level

This attribute indicates the Quality of Service level to be applied to the mobile client's traffic within the switching fabric, as well as over the air. This example shows a summary of the QoS-Level Attribute format. The fields are transmitted from left to right.

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|     Type      |  Length       |            Vendor-Id
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
     Vendor-Id (cont.)          | Vendor type   | Vendor length |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                          QoS Level                            |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

- Type – 26 for Vendor-Specific
- Length – 10
- Vendor-Id – 14179
- Vendor type – 2
- Vendor length – 4
- Value – Three octets:
  - 0 – Bronze (Background)
  - 1 – Silver (Best Effort)
  - 2 – Gold (Video)
  - 3 – Platinum (Voice)

ACL-Name

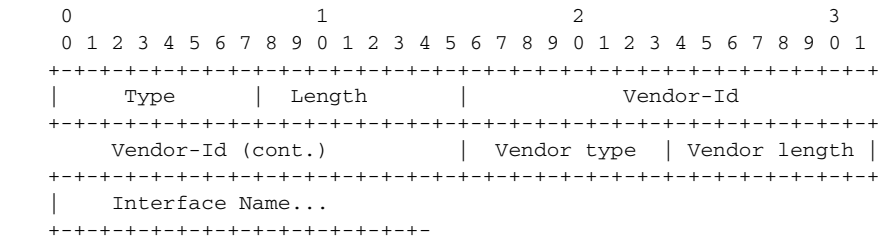
This attribute indicates the ACL name to be applied to the client. A summary of the ACL-Name Attribute format is shown below. The fields are transmitted from left to right.

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|     Type      |  Length       |            Vendor-Id
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
     Vendor-Id (cont.)          | Vendor type   | Vendor length |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|        ACL Name...
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
```

- Type – 26 for Vendor-Specific
- Length – >7
- Vendor-Id – 14179
- Vendor type – 6
- Vendor length – >0
- Value – A string that includes the name of the ACL to use for the client

Interface-Name

This attribute indicates the VLAN Interface a client is to be associated to. A summary of the Interface-Name Attribute format is shown below. The fields are transmitted from left to right.



- Type – 26 for Vendor-Specific
- Length – >7
- Vendor-Id – 14179
- Vendor type – 5
- Vendor length – >0
- Value – A string that includes the name of the interface the client is to be assigned to.

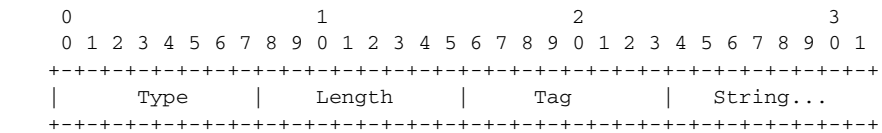
Note This Attribute only works when MAC Filtering is enabled, or if 802.1X or WPA is used as the security policy.

VLAN-Tag

This attribute indicates the group ID for a particular tunneled session, and is also known as the Tunnel-Private-Group-ID attribute.

This attribute might be included in the Access-Request packet if the tunnel initiator can predetermine the group resulting from a particular connection and should be included in the Access-Accept packet if this tunnel session is to be treated as belonging to a particular private group. Private groups may be used to associate a tunneled session with a particular group of users. For example, it may be used to facilitate routing of unregistered IP addresses through a particular interface. It should be included in Accounting-Request packets which contain Acct-Status-Type attributes with values of either Start or Stop and which pertain to a tunneled session.

A summary of the Tunnel-Private-Group-ID Attribute format is shown below. The fields are transmitted from left to right.



- Type – 81 for Tunnel-Private-Group-ID.
- Length – >= 3

- Tag – The Tag field is one octet in length and is intended to provide a means of grouping attributes in the same packet which refer to the same tunnel. If the value of the Tag field is greater than 0x00 and less than or equal to 0x1F, it should be interpreted as indicating which tunnel (of several alternatives) this attribute pertains. If the Tag field is greater than 0x1F, it should be interpreted as the first byte of the following String field.
- String – This field must be present. The group is represented by the String field. There is no restriction on the format of group IDs.

Tunnel Attributes

Note When any of the other RADIUS attributes in this section are returned, the Tunnel Attributes must also be returned.

Reference RFC2868 defines RADIUS tunnel attributes used for authentication and authorization, and RFC2867 defines tunnel attributes used for accounting. Where the IEEE 802.1X Authenticator supports tunneling, a compulsory tunnel may be set up for the Supplicant as a result of the authentication.

In particular, it may be desirable to allow a port to be placed into a particular Virtual LAN (VLAN), defined in IEEE8021Q, based on the result of the authentication. This can be used, for example, to allow a wireless host to remain on the same VLAN as it moves within a campus network.

The RADIUS server typically indicates the desired VLAN by including tunnel attributes within the Access-Accept. However, the IEEE 802.1X Authenticator may also provide a hint as to the VLAN to be assigned to the Supplicant by including Tunnel attributes within the Access- Request.

For use in VLAN assignment, the following tunnel attributes are used:

- Tunnel-Type=VLAN (13)
- Tunnel-Medium-Type=802
- Tunnel-Private-Group-ID=VLANID

Note that the VLANID is 12-bits, taking a value between 1 and 4094, inclusive. Since the Tunnel-Private-Group-ID is of type String as defined in RFC2868, for use with IEEE 802.1X, the VLANID integer value is encoded as a string.

When Tunnel attributes are sent, it is necessary to fill in the Tag field. As noted in RFC2868, section 3.1:

- The Tag field is one octet in length and is intended to provide a means of grouping attributes in the same packet which refer to the same tunnel. Valid values for this field are 0x01 through 0x1F, inclusive. If the Tag field is unused, it must be zero (0x00).
- For use with Tunnel-Client-Endpoint, Tunnel-Server-Endpoint, Tunnel-Private-Group-ID, Tunnel-Assignment-ID, Tunnel-Client-Auth-ID or Tunnel-Server-Auth-ID attributes (but not Tunnel-Type, Tunnel-Medium-Type, Tunnel-Password, or Tunnel-Preference), a tag field of greater than 0x1F is interpreted as the first octet of the following field.
- Unless alternative tunnel types are provided, (e.g. for IEEE 802.1X Authenticators that may support tunneling but not VLANs), it is only necessary for tunnel attributes to specify a single tunnel. As a result, where it is only desired to specify the VLANID, the tag field should be set to zero (0x00) in all tunnel attributes. Where alternative tunnel types are to be provided, tag values between 0x01 and 0x1F should be chosen.

CHAPTER 6

Configuring WLANs

This chapter describes how to configure up to 16 wireless LANs for your Cisco Wireless LAN Solution. This chapter contains these sections:

Wireless LAN Overview

The Cisco Wireless LAN Solution can control up to 16 wireless LANs for lightweight access points. Each wireless LAN has a separate wireless LAN ID (1 through 16), a separate wireless LAN SSID (wireless LAN name), and can be assigned unique security policies.

Lightweight access points broadcast all active Cisco Wireless LAN Solution wireless LAN SSIDs and enforce the policies that you define for each wireless LAN.

Note Cisco recommends that you assign one set of VLANs for wireless LANs and a different set of VLANs for Management Interfaces to ensure that controllers properly route VLAN traffic.

Configuring Wireless LANs

These sections describe how to configure wireless LANs:

Displaying, Creating, Disabling, and Deleting Wireless LANs

On the controller CLI, enter these commands to display, create, disable, and delete wireless LANs:

- Enter **show wlan summary** to display existing wireless LANs and whether they are enabled or disabled. Note that each wireless LAN is assigned a wireless LAN ID from 1 to 16.
- Enter **config wlan create** *wlan-id wlan-name* to create a new wireless LAN. For *wlan-id*, enter an ID from 1 to 16. For *wlan-name*, enter an SSID of up to 31 alphanumeric characters.

Note When wireless LAN 1 is created in the Configuration Wizard, it is created in enabled mode; disable it until you have finished configuring it. When you create a new wireless LAN using the **config wlan create** command, it is created in disabled mode; leave it disabled until you have finished configuring it.

- If you need to modify an enabled wireless LAN, disable it first using the **config wlan disable** *wlan-id* command. Leave wireless LANs in disabled mode until you finish configuring them.
- Enter **config wlan enable** *wlan-id* to enable a wireless LAN.
- Enter **config wlan delete** *wlan-id* to delete a wireless LAN.

Activating Wireless LANs

After you have completely configured your wireless LAN settings, enter **config wlan enable** *wlan-id* to activate the wireless LAN.

Assigning a Wireless LAN to a DHCP Server

Each wireless LAN can be assigned to a DHCP server. Any or all wireless LANs can be assigned to the same DHCP server, and each wireless LAN can be assigned to different DHCP servers.

Note DHCP servers must be assigned for wireless LANs that allow management through a wireless connection.

- Enter this command to assign a wireless LAN to a DHCP server:

  config wlan dhcp_server *wlan-id dhcp-server-ip-address*
- Enter **show wlan** to verify that the wireless LAN is assigned to the DHCP server.

Configuring MAC Filtering for Wireless LANs

When you use MAC filtering for client or administrator authorization, you need to enable it at the wireless LAN level first. If you plan to use local MAC address filtering for any wireless LAN, use the commands in this section to configure MAC filtering for a wireless LAN.

Enabling MAC Filtering

Use these commands to enable MAC filtering on a wireless LAN:

- Enter **config wlan mac-filtering enable** *wlan-id* to enable MAC filtering.
- Enter **show wlan** to verify that you have MAC filtering enabled for the wireless LAN.

When you enable MAC filtering, only the MAC addresses that you add to the wireless LAN are allowed to join the wireless LAN. MAC addresses that have not been added are not allowed to join the wireless LAN.

Creating a Local MAC Filter

Cisco Wireless LAN Controllers have built-in MAC filtering capability, similar to that provided by a RADIUS authorization server.

Use these commands to add MAC addresses to a wireless LAN MAC filter:

- Enter **show macfilter** to view MAC addresses assigned to wireless LANs.
- Enter **config macfilter add** *mac-addr wlan-id* to assign a MAC address to a wireless LAN MAC filter.
- Enter **show macfilter** to verify that MAC addresses are assigned to the wireless LAN.

Configuring a Timeout for Disabled Clients

You can configure a timeout for disabled clients. Clients who fail to authenticate three times when attempting to associate are automatically disabled from further association attempts. After the timeout period expires, the client is allowed to retry authentication until it associates or fails authentication and is excluded again. Use these commands to configure a timeout for disabled clients:

- Enter **config wlan blacklist** *wlan-id timeout* to configure the timeout for disabled clients. Enter a timeout from **1** to **65535** seconds, or enter **0** to permanently disable the client.
- Use the **show wlan** command to verify the current timeout.

Assigning Wireless LANs to VLANs

Use these commands to assign a wireless LAN to a VLAN:

- Enter this command to assign a wireless LAN to a VLAN:

  config wlan vlan *wlan-id* { **default** | **untagged** | *vlan-id controller-vlan-ip-address vlan-netmask vlan-gateway* }

  - Use the **default** option to assign the wireless LAN to the VLAN configured on the network port.
  - Use the **untagged** option to assign the wireless LAN to VLAN 0.
  - Use the *vlan-id, controller-vlan-ip-address, vlan-netmask,* and *vlan-gateway* options to assign the wireless LAN to a specific VLAN and to specify the controller VLAN IP address, the local IP netmask for the VLAN, and the local IP gateway for the VLAN.
- Enter **show wlan** to verify VLAN assignment status.

Note Cisco recommends that you assign one set of VLANs for wireless LANs and a different set of VLANs for management interfaces to ensure that controllers properly route VLAN traffic.

- To remove a VLAN assignment from a wireless LAN, use this command:

  config wlan vlan *wlan-id* **untagged**

Configuring Layer 2 Security

This section explains how to assign Layer 2 security settings to wireless LANs.

Dynamic 802.1X Keys and Authorization

Cisco Wireless LAN Controllers can control 802.1X dynamic WEP keys using EAP (extensible authentication protocol) across access points, and support 802.1X dynamic key settings for wireless LANs.

- Enter **show wlan** *wlan-id* to check the security settings of each wireless LAN. The default security setting for new wireless LANs is 802.1X with dynamic keys enabled. To maintain robust Layer 2 security, leave 802.1X configured on your wireless LANs.
- To disable or enable the 802.1X configuration, use this command:

  config wlan security 802.1X {**enable** | **disable**} *wlan-id*

- If you want to change the 802.1X encryption level for a wireless LAN, use this command:

  config wlan security 802.1X encryption *wlan-id* [**40 | 104 | 128**]

  - Use the 40 option to specify 40/64-bit encryption.
  - Use the 104 option to specify 104/128-bit encryption. (This is the default encryption setting.)
  - Use the 128 option to specify 128/152-bit encryption.

WEP Keys

Cisco Wireless LAN Controllers can control static WEP keys across access points. Use these commands to configure static WEP for wireless LANs:

- Enter this command to disable 802.1X encryption:

  config wlan security 802.1X disable *wlan-id*

- Enter this command to configure 40/64, 104/128, or 128/152-bit WEP keys:

  config wlan security static-wep-key encryption *wlan-id* {**40 | 104 | 128**} {**hex | ascii**} *key key-index*

  - Use the **40**, **104**, or **128** options to specify 40/64-bit, 104/128-bit, or 128/152-bit encryption. The default setting is 104/128.
  - Use the **hex** or **ascii** option to specify the character format for the WEP key.
  - Enter 10 hexadecimal digits (any combination of 0-9, a-f, or A-F) or five printable ASCII characters for 40-bit/64-bit WEP keys; enter 26 hexadecimal or 13 ASCII characters for 104-bit/128-bit keys; enter 32 hexadecimal or 16 ASCII characters for 128-bit/152-bit keys.
  - Enter a key index (sometimes called a key slot) **1** through **4**.

Note One unique WEP key index must be applied to each wireless LAN that uses static WEP. Because there are only four key indexes, only four wireless LANs can be configured for static WEP Layer 2 encryption. Also note that some legacy clients can only access key index 1 through 3 but cannot access key index 4.

Dynamic WPA Keys and Encryption

Cisco Wireless LAN Controllers can control WPA (Wi-Fi Protected Access) across access points. Enter these commands to configure WPA for a wireless LAN:

- Enter this command to disable 802.1X encryption:

  config wlan security 802.1X disable *wlan-id*

- Enter these commands to configure authorization and dynamic key exchange on a wireless LAN:
  - **config wlan security wpa enable** *wlan-id*
  - **config wlan security wpa encryption aes-ocb** *wlan-id*
  - **config wlan security wpa encryption tkip** *wlan-id*
  - **config wlan security wpa encryption wep** *wlan-id* {**40 | 104 | 128**}
- Enter **show wlan** to verify that you have WPA enabled.

Configuring a Wireless LAN for Both Static and Dynamic WEP

You can configure up to four wireless LANs to support static WEP keys, and you can also configure dynamic WEP on any of these static-WEP wireless LANs. Follow these guidelines when configuring a wireless LAN for both static and dynamic WEP:

- The static WEP key and the dynamic WEP key must be the same length.
- When you configure static and dynamic WEP as the Layer-2 security policy, no other security policies can be specified. For example, when you configure only dynamic WEP or only static WEP, you can also configure web authentication or IPSec. However, when you configure both static and dynamic WEP, you cannot also configure web authentication or IPSec.

Configuring Layer 3 Security

This section explains how to assign Layer 3 security settings to wireless LANs.

Note To use Layer 3 security on a Cisco 4100 Series Wireless LAN Controller, the controller must be equipped with a VPN/Enhanced Security Module (Crypto Module). The module plugs into the back of the controller and provides the extra processing power needed for processor-intensive security algorithms.

IPSec

IPSec (Internet Protocol Security) supports many Layer 3 security protocols. Enter these commands to enable IPSec on a wireless LAN:

- **config wlan security ipsec** {**enable** | **disable**} *wlan-id*
- Enter **show wlan** to verify that IPSec is enabled.

IPSec Authentication

IPSec uses hmac-sha-1 authentication as the default for encrypting wireless LAN data, but can also use hmac-md5, or no authentication. Enter this command to configure the IPSec IP authentication method:

- **config wlan security ipsec authentication** {**hmac-md5** | **hmac-sha-1** | **none**} *wlan-id*
- Enter **show wlan** to verify that the IPSec authentication method is configured.

IPSec Encryption

IPSec uses 3DES encryption as the default for encrypting wireless LAN data, but can also use AES, DES, or no encryption. Enter this command to configure the IPSec encryption method:

- config wlan security ipsec encryption {3des | aes | des | none} *wlan-id*
- Enter **show wlan** to verify that the IPSec encryption method is configured.

IKE Authentication

IPSec IKE (Internet Key Exchange) uses pre-shared key exchanges, x.509 (RSA Signatures) certificates, and XAuth-psk for authentication. Enter these commands to enable IPSec IKE on a wireless LAN that uses IPSec:

- **config wlan security ipsec ike authentication certificates** *wlan-id*
  - Use the **certificates** option to specify RSA signatures.
- **config wlan security ipsec ike authentication xauth-psk** *wlan-id key*
  - Use the **xauth-psk** option to specify XAuth pre-shared key.
  - For key, enter a pre-shared key from 8 to 255 case-sensitive ASCII characters.
- **config wlan security ipsec ike authentication pre-shared-key** *wlan-id key*
- Enter **show wlan** to verify that IPSec IKE is enabled.

IKE Diffie-Hellman Group

IPSec IKE uses Diffie-Hellman groups to block easily-decrypted keys. Enter these commands to configure the Diffie-Hellman group on a wireless LAN with IPSec enabled:

- **config wlan security ipsec ike DH-Group** *wlan-id group-id*
  - For *group-id*, enter **group-1**, **group-2** (this is the default setting), or **group-5**.
- Enter **show wlan** to verify that IPSec IKE DH group is configured.

IKE Phase 1 Aggressive and Main Modes

IPSec IKE uses the Phase 1 Aggressive (faster) or Main (more secure) mode to set up encryption between clients and the controller. Enter these commands to specify the Phase 1 encryption mode for a wireless LAN with IPSec enabled:

- **config wlan security ipsec ike phase1** {**aggressive** | **main**} *wlan-id*
- Enter **show wlan** to verify that the Phase 1 encryption mode is configured.

IKE Lifetime Timeout

IPSec IKE uses its timeout to limit the time that an IKE key is active. Enter these commands to configure an IKE lifetime timeout:

- **config wlan security ipsec ike lifetime** *wlan-id seconds*
  - For seconds, enter a number of seconds from 1800 to 345600 seconds. The default timeout is 28800 seconds.
- Enter **show wlan** to verify that the key timeout is configured.

IPSec Passthrough

IPSec IKE uses IPSec Passthrough to allow IPSec-capable clients to communicate directly with other IPSec equipment. IPSec Passthrough is also known as VPN Passthrough. Enter this command to enable IPSec Passthrough for a wireless LAN:

- config wlan security passthru {enable | disable} *wlan-id gateway*
  - For *gateway*, enter the IP address of the IPSec (VPN) passthrough gateway.
- Enter **show wlan** to verify that the passthrough is enabled.

Web-Based Authentication

Wireless LANs can use web authentication if IPSec is not enabled on the controller. Web Authentication is simple to set up and use, and can be used with SSL to improve the overall security of the wireless LAN. Enter these commands to enable web authentication for a wireless LAN:

- **config wlan security web** {**enable** | **disable**} *wlan-id*
- Enter **show wlan** to verify that web authentication is enabled.

Local Netuser

Cisco Wireless LAN Controllers have built-in network client authentication capability, similar to that provided by a RADIUS authentication server. Enter these commands to create a list of usernames and passwords allowed access to the wireless LAN:

- Enter **show netuser** to display client names assigned to wireless LANs.
- Enter **config netuser add** *username password wlan-id* to add a user to a wireless LAN.
- Enter **config netuser wlan-id** *username wlan-id* to add a user to a wireless LAN without specifying a password for the user.
- Enter **config netuser password** *username password* to create or change a password for a particular user.
- Enter **config netuser delete** *username* to delete a user from the wireless LAN.

Configuring Quality of Service

Cisco WLAN Solution wireless LANs support four levels of QoS: Platinum/Voice, Gold/Video, Silver/Best Effort (default), and Bronze/Background. You can configure the voice traffic wireless LAN to use Platinum QoS, assign the low-bandwidth wireless LAN to use Bronze QoS, and assign all other traffic between the remaining QoS levels. Enter these commands to assign a QoS level to a wireless LAN:

- **config wlan qos** *wlan-id* {**bronze** | **silver** | **gold** | **platinum**}
- Enter **show wlan** to verify that you have QoS properly set for each wireless LAN.

The wireless LAN QoS level (platinum, gold, silver, or bronze) defines a specific 802.11e user priority (UP) for over-the-air traffic. This UP is used to derive the over-the-wire priorities for non-WMM traffic, and it also acts as the ceiling when managing WMM traffic with various levels of priorities. The access point uses this QoS-profile-specific UP in accordance with the values in Table 6-1 to derive the IP DSCP value that is visible on the wired LAN.

Table 6-1 Access Point QoS Translation Values

AVVID 802.1p UP-Based Traffic Type	AVVID IP DSCP	AVVID 802.1p UP	IEEE 802.11e UP
Network control	–	7	–
Inter-network control (LWAPP control, 802.11 management)	48	6	7
Voice	46 (EF)	5	6
Video	34 (AF41)	4	5
Voice control	26 (AF31)	3	4
Background (Gold)	18 (AF21)	2	2
Background (Gold)	20 (AF22)	2	2
Background (Gold)	22 (AF23)	2	2
Background (Silver)	10 (AF11)	1	1
Background (Silver)	12 (AF12)	1	1
Background (Silver)	14 (AF13)	1	1
Best Effort	0 (BE)	0	0, 3
Background	2	0	1
Background	4	0	1
Background	6	0	1

Configuring QoS Enhanced BSS (QBSS)

You can enable QBSS in these two modes:

- Wireless Multimedia (WMM) mode, which supports devices that meet the 802.11E QBSS standard
- 7920 support mode, which supports Cisco 7920 IP telephones on your 802.11b/g network

QBSS is disabled by default.

Enabling WMM Mode

Enter this command to enable WMM mode:

config wlan wmm {**disabled** | **allowed** | **required**} *wlan-id*

- The **allowed** option allows client devices to use WMM on the wireless LAN.
- The **required** option requires client devices to use WMM; devices that do not support WMM cannot join the wireless LAN.

Note Do not enable WMM mode if Cisco 7920 phones are used on your network.

Enabling 7920 Support Mode

The 7920 support mode contains two options:

- Support for 7920 phones that require call admission control (CAC) to be configured on and advertised by the client device (these are typically older 7920 phones)
- Support for 7920 phones that require CAC to be configured on and advertised by the access point (these are typically newer 7920 phones)

Note When access-point-controlled CAC is enabled, the access point sends out a Cisco proprietary CAC Information Element (IE) and does not send out the standard QBSS IE.

Enter this command to enable 7920 support mode for phones that require client-controlled CAC:

config wlan 7920-support client-cac-limit {**enabled** | **disabled**} *wlan-id*

Note You cannot enable both WMM mode and client-controlled CAC mode on the same wireless LAN.

Enter this command to enable 7920 support mode for phones that require access-point-controlled CAC:

config wlan 7920-support ap-cac-limit {**enabled** | **disabled**} *wlan-id*

QBSS Information Elements Sometimes Degrade 7920 Phone Performance

If your wireless LAN contains both 1000 series access points and Cisco 7920 wireless phones, do not enable the WMM or AP-CAC-LIMIT QBSS information elements. Do not enter either of these commands:

config wlan 7920-support ap-cac-limit enable *wlan-id*

config wlan wmm [**allow** | **require**] *wlan-id*

The information sent by 1000 series access points in the WMM and AP-CAC-LIMIT QBSS information elements is inaccurate and could result in degradation of voice quality 7920 wireless phones. This issue does not affect the CLIENT-CAC-LIMIT QBSS IE, which you enable using this command:

config wlan 7920-support client-cac-limit enable *wlan-id*

The CLIENT-CAC-LIMIT QBSS IE is the only QBSS IE that should be used in networks containing both 1000 series access points and 7920 wireless phones.

Controlling Lightweight Access Points

This chapter describes how to connect access points to the controller and manage access point settings. This chapter contains these sections:

Lightweight Access Point Overview

This section describes Cisco lightweight access points.

Cisco 1000 Series IEEE 802.11a/b/g Lightweight Access Points

The Cisco 1000 series lightweight access point is a part of the innovative Cisco Wireless LAN Solution (Cisco Wireless LAN Solution). When associated with controllers as described below, the Cisco 1000 series lightweight access point provides advanced 802.11a and/or 802.11b/g Access Point functions in a single aesthetically pleasing plenum-rated enclosure. Figure 7-1 shows the two types of Cisco 1000 Series IEEE 802.11a/b/g lightweight access point: without and with connectors for external antennas.

Figure 7-1 1000 Series Lightweight Access Points

The Cisco WLAN Solution also offers 802.11a/b/g Cisco 1030 Remote Edge Lightweight Access Points, which are Cisco 1000 series lightweight access points designed for remote deployment, Radio Resource Management (RRM) control via a WAN link, and which include connectors for external antennas.

The Cisco 1000 series lightweight access point is manufactured in a neutral color so it blends into most environments (but can be painted), contains pairs of high-gain internal antennas for unidirectional (180-degree) or omnidirectional (360-degree) coverage, and is plenum-rated for installations in hanging ceiling spaces.

In the Cisco Wireless LAN Solution, most of the processing responsibility is removed from traditional SOHO (small office, home office) access points and resides in the Cisco Wireless LAN Controller.

Cisco 1030 Remote Edge Lightweight Access Points

The only exception to the general rule of lightweight access points being continuously controlled by Cisco Wireless LAN Controllers is the Cisco 1030 IEEE 802.11a/b/g remote edge lightweight access point (Cisco 1030 remote edge lightweight access point). The Cisco 1030 remote edge lightweight access point is intended to be located at a remote site, initially configured by a Cisco Wireless LAN Controller, and normally controlled by a Cisco Wireless LAN Controller.

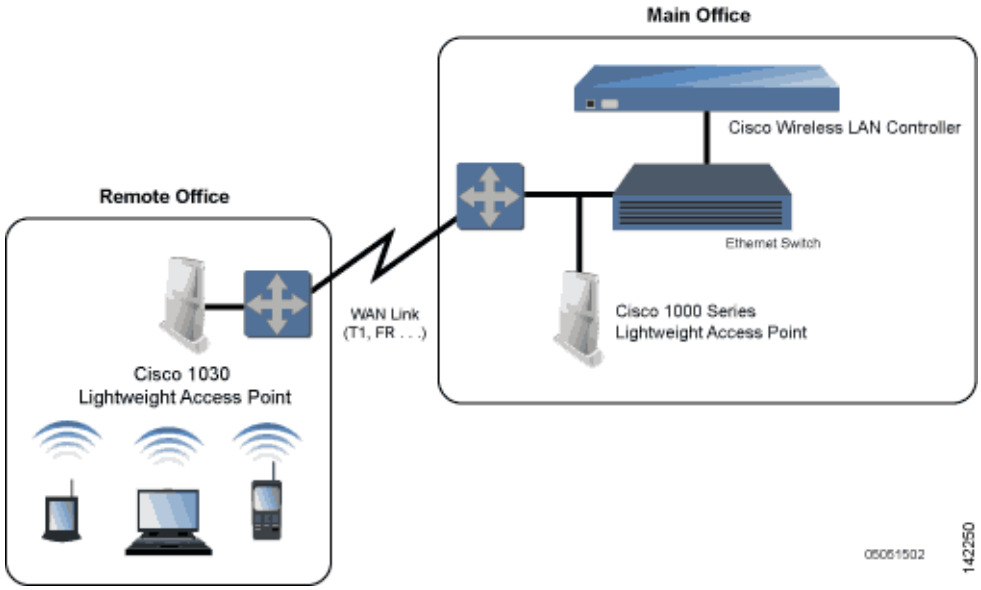
However, because the Cisco 1030 remote edge lightweight access point bridges the client data (compared with other Cisco 1000 series lightweight access points, which pass all client data through their respective Cisco Wireless LAN Controller), if the WAN link breaks between the Cisco 1030 remote edge lightweight access point and its Cisco Wireless LAN Controller, the Cisco 1030 remote edge lightweight access point continues transmitting wireless LAN 1 client data through other Cisco 1030 remote edge lightweight access points on its local subnet. However, it cannot take advantage of features accessed from the Cisco Wireless LAN Controller, such as establishing new VLANs, until communication is reestablished.

The Cisco 1030 remote edge lightweight access point includes the traditional SOHO (small office, home office) AP processing power, and thus can continue operating if the WAN link to its associated Cisco Wireless LAN Controller fails. Because it is configured by its associated Cisco Wireless LAN Controller, it has the same wireless LAN configuration as the rest of the Cisco Wireless LAN Solution. As long as it remains connected to its Cisco Wireless LAN Controller, it varies its transmit power and channel selection under control of the RRM, and performs the same rogue access point location as any other Cisco 1000 series lightweight access point.

Note that the Cisco 1030 remote edge lightweight access point can support multiple wireless LANs while it is connected to its Cisco Wireless LAN Controller. However, when it loses connection to its Cisco Wireless LAN Controller, it supports only one wireless LAN on its local subnet.

Figure 7-2 shows a typical Cisco 1030 remote edge lightweight access point configuration:

Figure 7-2 Typical 1030 Lightweight Access Point Configuration



Note that the Cisco 1030 remote edge lightweight access point must have a DHCP server available on its local subnet, so it can obtain an IP address upon reboot. Also note that the Cisco 1030 remote edge lightweight access points at each remote location must be on the same subnet to allow client roaming.

Cisco 1000 Series Lightweight Access Point Part Numbers

The Cisco 1000 series lightweight access point includes one 802.11a and one 802.11b/g radio. The Cisco 1000 series lightweight access point is available in the following configurations:

- AIR-AP1010-A-K9, AIR-AP1010-C-K9, AIR-AP1010-E-K9, AIR-AP1010-J-K9, AIR-AP1010-N-K9, and AIR-AP1010-S-K9 — AP1010 Cisco 1000 series lightweight access point with four high-gain internal antennas, and no external antenna adapters.
- AIR-AP1020-A-K9, AIR-AP1020-C-K9, AIR-AP1020-E-K9, AIR-AP1020-J-K9, AIR-AP1020-N-K9, and AIR-AP1020-S-K9 — AP1020 Cisco 1000 series lightweight access point with four high-gain internal antennas, and one 5 GHz external antenna adapter and two 2.4 GHz external antenna adapters.
- AIR-AP1030-A-K9, AIR-AP1030-C-K9, AIR-AP1030-E-K9, AIR-AP1030-J-K9, AIR-AP1030-N-K9, and AIR-AP1030-S-K9 — AP1030 Cisco 1000 series lightweight access point (Cisco 1030 remote edge lightweight access point) with four high-gain internal antennas, and one 5 GHz external antenna adapter and two 2.4 GHz external antenna adapters.

Refer to Appendix D, "Supported Country Codes" for information on supported regulatory domains.

The Cisco 1000 series lightweight access point is shipped with a color-coordinated ceiling mount base and hanging-ceiling rail clips. You can also order projection- and flush-mount sheet metal wall mounting bracket kits. The base, clips, and optional brackets allow quick mounting to ceiling or wall.

The Cisco 1000 series lightweight access point can be powered by Power over Ethernet or by an external power supply. The external power supply model is:

- AIR-PWR-1000 — Optional External 110-220 VAC-to-48 VDC Power Supply for any Cisco 1000 series lightweight access point.

The Single Inline PoE injector model is:

- AIR-PWRINJ-1000AF — Optional Single 802.3af Inline Power over Ethernet Injector for any Cisco 1000 series lightweight access point, powered by 90-250 VAC.

The projection and flush sheet metal wall mount bracket model is:

- AIR-ACC-WBRKT1000 — Optional sheet metal wall-mount bracket kit for any Cisco 1000 series lightweight access point. Includes one projection-mount and one flush-mount bracket per kit.

Cisco 1000 Series Lightweight Access Point External and Internal Antennas

The Cisco 1000 series lightweight access point enclosure contains one 802.11a or one 802.11b/g radio and four (two 802.11a and two 802.11b/g) high-gain antennas, which can be independently enabled or disabled to produce a 180-degree sectorized or 360-degree omnidirectional coverage area.

Note Cisco 1000 Series lightweight access points must use the factory-supplied internal or external antennas to avoid violating FCC requirements and voiding the user's authority to operate the equipment.

Note that the wireless LAN operator can disable either one of each pair of the Cisco 1000 series lightweight access point internal antennas to produce a 180-degree sectorized coverage area. This feature can be useful, for instance, for outside-wall mounting locations where coverage is only desired inside the building, and in a back-to-back arrangement that can allow twice as many clients in a given area.

Refer to Appendix E, "Antenna Patterns for 1000 Series Access Points" for antenna patterns.

External Antenna Connectors

The AP1020 and AP1030 Cisco 1000 series lightweight access points have male reverse-polarity TNC jacks for installations requiring factory-supplied external directional or high-gain antennas. The external antenna option can create more flexibility in Cisco 1000 series lightweight access point antenna placement.

Note The AP1010 Cisco 1000 Series lightweight access points are designed to be used exclusively with the internal high-gain antennas, and have no jacks for external antennas.

Note that the 802.11b/g 2.4 GHz Left external antenna connector is associated with the internal Side A antenna, and that the 2.4 GHz Right external antenna connector is associated with the internal Side B antenna. When you have 802.11b/g diversity enabled, the Left external or Side A internal antennas are diverse from the Right external or Side B internal antennas.

Also note that the 802.11a 5 GHz Left external antenna connector is separate from the internal antennas, and adds diversity to the 802.11a transmit and receive path. Note that no external 802.11a antennas are certified in FCC-regulated areas, but external 802.11a antennas may be certified for use in other countries.

Antenna Sectorization

Note that the Cisco WLAN Solution supports Antenna Sectorization, which can be used to increase the number of clients and/or client throughput a given air space. Installers can mount two Cisco 1000 series lightweight access points back-to-back, and the Network operator can disable the second antenna in both access points to create a 360-degree coverage area with two sectors.

Installers can also mount Cisco 1000 series lightweight access points on the periphery of a building and disable the Side B internal antennas. This configuration can be used to supply service to the building interior without extending coverage to the parking lot, at the cost of eliminating the internal antenna diversity function.

Refer to Appendix E: Internal Antenna Patterns for information on the radiation patterns of internal antennas in 1000 series lightweight access points.

Cisco 1000 Series Lightweight Access Point LEDs

Each Cisco 1000 series lightweight access point is equipped with four LEDs across the top of the case. They can be viewed from nearly any angle. The LEDs indicate power and fault status, 2.4 GHz (802.11b/g) Cisco Radio activity, and 5 GHz (802.11a) Cisco Radio activity.

This LED display allows the wireless LAN manager to quickly monitor the Cisco 1000 series lightweight access point status. For more detailed troubleshooting instructions, refer to the Error Messages and Access Point LEDs appendix.

Cisco 1000 Series Lightweight Access Point Connectors

The AP1020 and AP1030 Cisco 1000 series lightweight access points have the following external connectors:

- One RJ-45 Ethernet jack, used for connecting the Cisco 1000 series lightweight access point to the network.
- One 48 VDC power input jack, used to plug in an optional factory-supplied external power adapter.
- Three male reverse-polarity TNC antenna jacks, used to plug optional external antennas into the Cisco 1000 series lightweight access point: two for an 802.11b/g radio, and one for an 802.11a radio.

Note The AP1010 Cisco 1000 Series lightweight access points are designed to be used exclusively with the internal high-gain antennas, and have no jacks for external antennas.

The Cisco 1000 series lightweight access point communicates with a Cisco Wireless LAN Controller using standard CAT-5 (Category 5) or higher 10/100 Mbps twisted pair cable with RJ-45 connectors. Plug the CAT-5 cable into the RJ-45 jack on the side of the Cisco 1000 series lightweight access point.

Note that the Cisco 1000 series lightweight access point can receive power over the CAT-5 cable from network equipment. Refer to Power over Ethernet for more information about this option.

The Cisco 1000 series lightweight access point can be powered from an optional factory-supplied external AC-to-48 VDC power adapter. If you are powering the Cisco 1000 series lightweight access point using an external adapter, plug the adapter into the 48 VDC power jack on the side of the Cisco 1000 series lightweight access point.

The Cisco 1000 series lightweight access point includes two 802.11a and two 802.11b/g high-gain internal antennas, which provide omnidirectional coverage. However, some Cisco 1000 series lightweight access points can also use optional factory-supplied external high-gain and/or directional antennas. When you are using external antennas, plug them into the male reverse-polarity TNC jacks on the side of the AP1020 and AP1030 Cisco 1000 series lightweight access points.

Note Cisco 1000 Series lightweight access points must use the factory-supplied internal or external antennas to avoid violating FCC requirements and voiding the user's authority to operate the equipment.

Cisco 1000 Series Lightweight Access Point Power Requirements

Each Cisco 1000 series lightweight access point requires a 48 VDC nominal (between 38 and 57 VDC) power source capable of providing 7 Watts. The polarity of the DC source does not matter because the Cisco 1000 series lightweight access point can use either a +48 VDC or a -48 VDC nominal source.

Cisco 1000 series lightweight access points can receive power from the external power supply (which draws power from a 110-220 VAC electrical outlet) plugged into the side of the access point case, or from Power over Ethernet.

Cisco 1000 Series Lightweight Access Point External Power Supply

The Cisco 1000 series lightweight access point can receive power from an external 110-220 VAC-to-48 VDC power supply or from Power over Ethernet equipment.

The external power supply (AIR-PWR-1000) plugs into a secure 110 through 220 VAC electrical outlet. The converter produces the required 48 VDC output for the Cisco 1000 series lightweight access point. The converter output feeds into the side of the Cisco 1000 series lightweight access point through a 48 VDC jack.

Note that the AIR-PWR-1000 external power supply can be ordered with country-specific electrical outlet power cords. Contact Cisco when ordering to receive the correct power cord.

Cisco 1000 Series Lightweight Access Point Mounting Options

Refer to the *Internal-Antenna AP1010 Cisco 1000 Series IEEE 802.11a/b/g Lightweight Access Point Quick Start Guide* or the *External-Antenna AP1020 and AP1030 Cisco 1000 Series IEEE 802.11a/b/g Lightweight Access Point Quick Start Guide* for the Cisco 1000 series lightweight access point mounting options.

Cisco 1000 Series Lightweight Access Point Physical Security

The side of the Cisco 1000 series lightweight access point housing includes a slot for a Kensington MicroSaver Security Cable. Refer to the Kensington website for more information about their security products, or to the *Internal-Antenna AP1010 Cisco 1000 Series IEEE 802.11a/b/g Lightweight Access Point Quick Start Guide* or *External-Antenna AP1020 and AP1030 Cisco 1000 Series IEEE 802.11a/b/g Lightweight Access Point Quick Start Guide* for installation instructions.

Cisco 1000 Series Lightweight Access Point Monitor Mode

The Cisco 1000 series lightweight access points and Cisco Wireless LAN Controllers can perform rogue access point detection and containment while providing regular service. The rogue access point detection is performed across all 801.11 channels, regardless of the Country Code selected.

However, if the administrator would prefer to dedicate specific Cisco 1000 series lightweight access points to rogue access point detection and containment, the Monitor mode should be enabled for individual Cisco 1000 series lightweight access points.

The Monitor function is set for all 802.11 Cisco Radios on a per-access point basis using any of the Cisco Wireless LAN Controller user interfaces.

Using the DNS for Controller Discovery

In Cisco Wireless LAN Solution software releases 3.0 and later, access points can discover controllers through your domain name server (DNS). To use this feature you configure your DNS to return controller IP addresses in response to CISCO-LWAPP-CONTROLLER.*localdomain*. When an access point receives an IP address and DNS information from a DHCP server, it contacts the DNS to resolve CISCO-LWAPP-CONTROLLER.*localdomain*. When the DNS sends a list of controller IP addresses, the access point sends discovery requests to the controllers.

Dynamic Frequency Selection

The Cisco Wireless LAN solution complies with regulations in Europe and Singapore that require radio devices to use Dynamic Frequency Selection (DFS) to detect radar signals and avoid interfering with them.

When a lightweight access point with a 5-GHz radio operates on one of the 15 channels listed in Table 7-1, the controller to which the access point is associated automatically uses DFS to set the operating frequency.

When you manually select a channel for DFS-enabled 5-GHz radios, the controller checks for radar activity on the channel for 60 seconds. If there is no radar activity, the access point operates on the channel you selected. If there is radar activity on the channel you selected the controller automatically selects a different channel, and after 30 minutes, the access point re-tries the channel you selected.

Note The Rogue Location Detection Protocol (RLDP) is not supported on the channels listed in Table 7-1.

Note The maximum legal transmit power is greater for some 5-GHz channels than for others. When it randomly selects a 5-GHz channel on which power is restricted, the controller automatically reduces transmit power to comply with power limits for that channel.

Table 7-1 5-GHz Channels on Which DFS is Automatically Enabled

52 (5260 MHz)	104 (5520 MHz)	124 (5620 MHz)
56 (5280 MHz)	108 (5540 MHz)	128 (5640 MHz)
60 (5300 MHz)	112 (5560 MHz)	132 (5660 MHz)
64 (5320 MHz)	116 (5580 MHz)	136 (5680 MHz)
100 (5500 MHz)	120 (5600 MHz)	140 (5700 MHz)

Using DFS, the controller monitors operating frequencies for radar signals. If it detects radar signals on a channel, the controller takes these steps:

- It changes the access point channel to a channel that has not shown radar activity. The controller selects the channel at random.
- If the channel selected is one of the channels in Table 7-1, it scans the new channel for radar signals for 60 seconds. If there are no radar signals on the new channel, the controller accepts client associations.
- It records the channel that showed radar activity as a radar channel and prevents activity on that channel for 30 minutes.
- It generates a trap to alert the network manager.

Autonomous Access Points Converted to Lightweight Mode

You can use an upgrade conversion tool to convert autonomous Cisco Aironet 1130AG, 1200, and 1240AG Series Access Points to lightweight mode. When you upgrade one of these access points to lightweight mode, the access point communicates with a wireless LAN controller and receives a configuration and software image from the controller.

Refer to these documents for complete instructions on upgrading an autonomous access point to lightweight mode:

- *Release Notes for Cisco Aironet 1130AG, 1200, and 1240AG Series Access Points for Cisco IOS Release 12.3(7)JX*
- *Application Note: Upgrading Autonomous Cisco Aironet Access Points to Lightweight Mode*

Guidelines for Using Access Points Converted to Lightweight Mode

Keep these guidelines in mind when you use autonomous access points that have been converted to lightweight mode:

- Converted access points support 2006, 4400, and WiSM controllers only. When you convert an autonomous access point to lightweight mode, the access point can communicate with Cisco 2006 series wireless LAN controllers, 4400 series controllers, or the controllers on a Wireless Services Module (WiSM) only. Cisco 4100 series, Airespace 4012 series, and Airespace 4024 series controllers are not supported because lack the memory required to support access points running Cisco IOS software.
- Access points converted to lightweight mode do not support Wireless Domain Services (WDS). Converted access points communicate only with Cisco wireless LAN controllers and cannot communicate with WDS devices. However, the controller provides functionality equivalent to WDS when the access point associates to it.
- Access points converted to LWAPP mode support 8 BSSIDs per radio and a total of 8 wireless LANs per access point. (Cisco 1000 series access points support 16 BSSIDs per radio and 16 wireless LANs per access point.) When a converted access point associates to a controller, only wireless LANs with IDs 1 through 8 are pushed to the access point.
- Access points converted to lightweight mode do not support Layer 2 LWAPP. Access Points converted to lightweight mode must get an IP address and discover the controller using DHCP, DNS, or IP subnet broadcast.
- After you convert an access point to lightweight mode, the console port provides read-only access to the unit.

Reverting from Lightweight Mode to Autonomous Mode

After you use the upgrade tool to convert an autonomous access point to lightweight mode, you can convert the access point from a lightweight unit back to an autonomous unit by loading a Cisco IOS release that supports autonomous mode (Cisco IOS release 12.3(7)JA or earlier). If the access point is associated to a controller, you can use the controller to load the Cisco IOS release. If the access point is not associated to a controller, you can load the Cisco IOS release using TFTP. In either method, the access point must be able to access a TFTP server that contains the Cisco IOS release to be loaded.

Using a Controller to Return to a Previous Release

Follow these steps to revert from lightweight mode to autonomous mode using a wireless LAN controller:

Step 1 Log into the CLI on the controller to which the access point is associated.

Step 2 Enter this command:

config ap tftp-downgrade *tftp-server-ip-address filename access-point-name*

Step 3 Wait until the access point reboots and reconfigure the access point using the CLI or GUI.

Using the MODE Button and a TFTP Server to Return to a Previous Release

Follow these steps to revert from lightweight mode to autonomous mode by using the access point MODE (reset) button to load a Cisco IOS release from a TFTP server:

Step 1 The PC on which your TFTP server software runs must be configured with a static IP address in the range of 10.0.0.2 to 10.0.0.30.

Step 2 Make sure that the PC contains the access point image file (such as *c1200-k9w7-tar.123-7.JA.tar* for a 1200 series access point) in the TFTP server folder and that the TFTP server is activated.

Step 3 Rename the access point image file in the TFTP server folder to **c1200-k9w7-tar.default** for a 1200 series access point.

Step 4 Connect the PC to the access point using a Category 5 (CAT5) Ethernet cable.

Step 5 Disconnect power from the access point.

Step 6 Press and hold the **MODE** button while you reconnect power to the access point.

Note The MODE button on the access point must be enabled. Follow the steps in the "Disabling the Reset Button on Access Points Converted to Lightweight Mode" section on page 7-13 to check the status of the access point MODE button.

Step 7 Hold the **MODE** button until the status LED turns red (approximately 20 to 30 seconds), and release the MODE button.

Step 8 Wait until the access point reboots as indicated by all LEDs turning green followed by the Status LED blinking green.

Step 9 After the access point reboots, reconfigure the access point using the GUI or the CLI.

Controllers Accept SSCs from Access Points Converted to Lightweight Mode

The lightweight access point protocol (LWAPP) secures the control communication between the access point and controller by means of a secure key distribution requiring X.509 certificates on both the access point and controller. LWAPP relies on a priori provisioning of the X.509 certificates. Factory installed certificates are referenced by the term *MIC*, which is an acronym for manufacturing-installed certificate. Cisco Aironet access points shipped before July 18, 2005 do not have a MIC, so these access points create a self-signed certificate (SSC) when upgraded to operate in lightweight mode. Controllers are programmed to accept SSCs for authentication of specific access points.

Using DHCP Option 43

Cisco 1000 series access points use a string format for DHCP option 43, whereas Cisco Aironet access points use the type-length-value (TLV) format for DHCP option 43. DHCP servers must be programmed to return the option based on the access point's DHCP Vendor Class Identifier (VCI) string (DHCP Option 60). Table 7-2 lists the VCI strings for Cisco access points capable of operating in lightweight mode.

Table 7-2 VCI Strings For Lightweight Access Points

Access Point	VCI String
Cisco 1000 Series	Airespace 1200
Cisco Aironet 1130 Series	Cisco AP c1130
Cisco Aironet 1200 Series	Cisco AP c1200
Cisco Aironet 1240 Series	Cisco AP c1240

This is the format of the TLV block:

- Type: 0xf1 (decimal 241)
- Length: Number of controller IP addresses * 4
- Value: List of the IP addresses of controller management interfaces

Refer to the product documentation for your DHCP server for instructions on configuring DHCP Option 43. The *Application Note: Upgrading Autonomous Cisco Aironet Access Points To Lightweight Mode* contains example steps for configuring option 43 on a DHCP server.

Using a Controller to Send Debug Commands to Access Points Converted to Lightweight Mode

Enter this command to enable the controller to send debug commands to an access point converted to lightweight mode:

config ap remote-debug [**enable** | **disable** | **exc_command**] *access-point-name*

When this feature is enabled, the controller sends debug commands to the converted access point as character strings. You can send any debug command supported by Cisco Aironet access points that run Cisco IOS software in lightweight mode.

Converted Access Points Send Crash Information to Controller

When a converted access point unexpectedly reboots, the access point stores a crash file on its local flash memory at the time of crash. After the unit reboots, it sends the reason for the reboot to the controller. If the unit rebooted because of a crash, the controller pulls up the crash file using existing LWAPP messages and stores it in the controller flash memory. The crash info copy is removed from the access point flash memory when the controller pulls it from the access point.

Converted Access Points Send Radio Core Dumps to Controller

When a radio module in a converted access point generates a core dump, the access point stores the core dump file of the radio on its local flash memory at the time of the radio crash. It sends a notification message to the controller indicating which radio generated a core dump file. The controller sends a trap alerting the network administrator, and the administrator can retrieve the radio core file from the access point.

On the controller CLI, enter this command to pull the core file from the access point:

config ap get-radio-core-dump *slot ap-name*

For *slot*, enter the radio interface number on the access point.

The retrieved core file is stored in the controller flash and can subsequently be uploaded through TFTP to an external server for analysis. The core file is removed from the access point flash memory when the controller pulls it from the access point.

Enabling Memory Core Dumps from Converted Access Points

By default, access points converted to lightweight mode do not send memory core dumps to the controller. To enable this feature, enter this command:

config ap core-dump enable *tftp-server-ip-address filename* {**compress** | **uncompress**} {*ap-name* | **all**}

- For *tftp-server-ip-address*, enter the IP address of the TFTP server to which the access point sends core files. The access point must be able to reach the TFTP server.
- For *filename*, enter a filename that the access points uses to label the core file.
- Enter **compress** to configure the access point to send compressed core files. Enter **uncompress** to configure the access point to send uncompressed core files.
- For *ap-name*, enter the name of a specific access point, or enter **all** to enable memory core dumps from all access points converted to lightweight mode.

Display of MAC Addresses for Converted Access Points

There are some differences in the way that controllers display the MAC addresses of converted access points on information pages in the controller GUI:

- On the AP Summary page, the controller lists the Ethernet MAC addresses of converted access points.
- On the AP Detail page, the controller lists the BSS MAC addresses and Ethernet MAC addresses of converted access points.
- On the Radio Summary page, the controller lists converted access points by radio MAC address.

Disabling the Reset Button on Access Points Converted to Lightweight Mode

You can disable the reset button on access points converted to lightweight mode. The reset button is labeled MODE on the outside of the access point.

Use this command to disable or enable the reset button on one or all converted access points associated to a controller:

config ap reset-button {**enable** | **disable**} {*ap-name* | **all**}

The reset button on converted access points is enabled by default.

Configuring a Static IP Address on an Access Point Converted to Lightweight Mode

After an access point converted to lightweight mode associates to a controller, enter this command to configure a static IP address on the access point:

config ap static-ip enable *ap-name ip-address mask gateway*

CHAPTER 8

Managing Controller Software and Configurations

This chapter describes how to manage configurations and software versions on the controllers. This chapter contains these sections:

Transferring Files to and from a Controller

Controllers have built-in utilities for uploading and downloading software, certificates, and configuration files.

Use these **transfer** commands:

- **transfer download datatype**
- **transfer download filename**
- **transfer download mode**
- **transfer download path**
- **transfer download serverip**
- **transfer download start**
- **transfer upload datatype**
- **transfer upload filename**
- **transfer upload mode**
- **transfer upload path**
- **transfer upload serverip**
- **transfer upload start**

Upgrading Controller Software

Follow these steps to upgrade the controller software using the CLI.

Note You can also update the controller software using the GUI or through a wireless connection. However, in these cases, you will lose your connection to the controller sometime during the update process. For this reason, Cisco recommends that you use a direct CLI console port connection to update controller software.

Step 1 Make sure you have a TFTP server available for the Operating System software download. Keep these guidelines in mind when setting up a TFTP server:

- If you are downloading through the Service port, the TFTP server must be on the same subnet as the service port, because the service port is not routable.
- If you are downloading through the DS (Distribution System) network port, the TFTP server can be on the same or a different subnet, because the DS port is routable.
- The TFTP server cannot run on the same computer as WCS because WCS and the TFTP server use the same communication port.

Step 2 Download the desired Operating System software update file from the Cisco website to the default directory on your TFTP server.

Step 3 Log into the controller CLI.

Step 4 Enter **ping** *server-ip-address* to verify that the controller can contact the TFTP server.

Step 5 Enter **transfer download start** and answer **n** to the prompt to view the current download settings. This example shows the command output:

```
>transfer download start
Mode..................................... TFTP
Data Type................................ Code
TFTP Server IP........................... xxx.xxx.xxx.xxx
TFTP Path................................ <directory path>
TFTP Filename............................ AS_2000_3_0_x_x.aes --OR--
                                          AS_4100_3_0_x_x.aes --OR--
                                          AS_4400_3_0_x_x.aes

Are you sure you want to start? (y/n) n
Transfer Canceled
>
```

Step 6 Enter these commands to change the download settings:

transfer download mode tftp

transfer download datatype code

transfer download serverip *tftp-server-ip-address*

transfer download filename *filename*

transfer download path *absolute-tftp-server-path-to-file*

Note All TFTP servers require the full pathname. For example, in Windows, the path is C:\TFTP-Root. (In UNIX forward slashes "/" are required.)

Step 7 Enter **transfer download start** to view the updated settings, and answer **y** to the prompt to confirm the current download settings and start the Operating System code download. This example shows the download command output:

```
transfer download start
Mode..................................... TFTP
Data Type................................ Code
TFTP Server IP........................... xxx.xxx.xxx.xxx
TFTP Path................................ <directory path>
TFTP Filename............................ AS_2000_3_0_x_x.aes --OR--
                                          AS_4100_3_0_x_x.aes --OR--
                                          AS_4400_3_0_x_x.aes

Are you sure you want to start? (y/n) y
TFTP Code transfer starting.
TFTP receive complete... extracting components.
Writing new bootloader to flash.
Making backup copy of RTOS.
Writing new RTOS to flash.
Making backup copy of Code.
Writing new Code to flash.
TFTP File transfer operation completed successfully.
  Please restart the switch (reset system) for update to complete.
```

Step 8 The controller now has the code update in active volatile RAM, but you must enter **reset system** to save the code update to non-volatile NVRAM and reboot the Cisco Wireless LAN Controller:

```
reset system
The system has unsaved changes.
Would you like to save them now? (y/n) y
```

The controller completes the bootup process.

Saving Configurations

Controllers contain two kinds of memory: volatile RAM and NVRAM. At any time, you can save the configuration changes from active volatile RAM to non-volatile RAM (NVRAM) using one of these commands:

- Use the **save config** command. This command saves the configuration from volatile RAM to NVRAM without resetting the controller.
- Use the **reset system** command. The CLI prompts you to confirm that you want to save configuration changes before the controller reboots.
- Use the **logout** command. The CLI prompts you to confirm that you want to save configuration changes before you log out.

Clearing the Controller Configuration

Follow these steps to clear the active configuration in NVRAM.

Step 1 Enter **clear config** and enter **y** at the confirmation prompt to confirm the action.

Step 2 Enter **reset system**. At the confirmation prompt, enter **n** to reboot without saving configuration changes. When the controller reboots, the configuration wizard starts automatically.

Step 3 Follow the instructions in the "Using the Configuration Wizard" section on page 4-2 to complete the initial configuration.

Erasing the Controller Configuration

Follow these steps to reset the controller configuration to default settings:

Step 1 Enter **reset system**. At the confirmation prompt, enter **y** to save configuration changes to NVRAM. The controller reboots.

Step 2 When you are prompted for a username, enter **recover-config** to restore the factory default configuration. The controller reboots and the configuration wizard starts automatically.

Step 3 Follow the instructions in the "Using the Configuration Wizard" section on page 4-2 to complete the initial configuration.

Resetting the Controller

You can reset the controller and view the reboot process on the CLI console using one of the following two methods:

- Turn the controller off and then turn it back on.
- On the CLI, enter **reset system**. At the confirmation prompt, enter **y** to save configuration changes to NVRAM. The controller reboots.

When the controller reboots, the CLI console displays the following reboot information:

- Initializing the system.
- Verifying the hardware configuration.
- Loading microcode into memory.
- Verifying the Operating System software load.
- Initializing with its stored configurations.
- Displaying the login prompt.

CHAPTER 9

Configuring Radio Resource Management

This chapter describes radio resource management (RRM) and explains how to configure it on the controllers. It contains these sections:

Overview of Radio Resource Management

The *radio resource management (RRM)* software embedded in the controller acts as a built-in RF engineer to consistently provide real-time RF management of your wireless network. RRM enables controllers to continually monitor their associated lightweight access points for the following information:

- **Traffic load**—The total bandwidth used for transmitting and receiving traffic. It enables wireless LAN managers to track and plan network growth ahead of client demand.
- **Interference**—The amount of traffic coming from other 802.11 sources.
- **Noise**—The amount of non-802.11 traffic that is interfering with the currently assigned channel.
- **Coverage**—The received signal strength (RSSI) and signal-to-noise ratio (SNR) for all connected clients.
- **Other access points**—The number of nearby access points.

Using this information, RRM can periodically reconfigure the 802.11 RF network for best efficiency. To do this, RRM performs these functions:

- Radio resource monitoring
- Dynamic channel assignment
- Dynamic transmit power control
- Coverage hole detection and correction
- Client and network load balancing

Radio Resource Monitoring

RRM automatically detects and configures new controllers and lightweight access points as they are added to the network. It then automatically adjusts associated and nearby lightweight access points to optimize coverage and capacity.

Lightweight access points can simultaneously scan all valid 802.11a/b/g channels for the country of operation as well as for channels available in other locations. The access point goes “off-channel” for a period not greater than 60 ms to monitor these channels for noise and interference. Packets collected during this time are analyzed to detect rogue access points, rogue clients, ad-hoc clients, and interfering access points.

Note If packets have been in the voice queue in the last 100 ms, the access point does not go off-channel.

By default, each access point spends only 0.2 percent of its time off-channel. This activity is distributed across all access points so that adjacent access points are not scanning at the same time, which could adversely affect wireless LAN performance. In this way, administrators gain the perspective of every access point, thereby increasing network visibility.

Dynamic Channel Assignment

Two adjacent access points on the same channel can cause either signal contention or signal collision. In the case of a collision, data is simply not received by the access point. This functionality can become a problem, for example, when someone reading e-mail in a café affects the performance of the access point in a neighboring business. Even though these are completely separate networks, someone sending traffic to the café on channel 1 can disrupt communication in an enterprise using the same channel. Controllers address this problem by dynamically allocating access point channel assignments to avoid conflict and to increase capacity and performance. Channels are "reused" to avoid wasting scarce RF resources. In other words, channel 1 is allocated to a different access point far from the café, which is more effective than not using channel 1 altogether.

The controller's dynamic channel assignment capabilities are also useful in minimizing adjacent channel interference between access points. For example, two overlapping channels in the 802.11b/g band, such as 1 and 2, cannot both simultaneously use 11/54 Mbps. By effectively reassigning channels, the controller keeps adjacent channels separated, thereby avoiding this problem.

The controller examines a variety of real-time RF characteristics to efficiently handle channel assignments. These include:

- **Access point received energy**—The received signal strength measured between each access point and its nearby neighboring access points. Channels are optimized for the highest network capacity.
- **Noise**—Noise can limit signal quality at the client and access point. An increase in noise reduces the effective cell size and degrades user experience. By optimizing channels to avoid noise sources, the controller can optimize coverage while maintaining system capacity. If a channel is unusable due to excessive noise, that channel can be avoided.
- **802.11 Interference**—*Interference* is any 802.11 traffic that is not part of your wireless LAN, including rogue access points and neighboring wireless networks. Lightweight access points constantly scan all channels looking for sources of interference. If the amount of 802.11 interference exceeds a predefined configurable threshold (the default is 10 percent), the access point sends an alert to the controller. Using the RRM algorithms, the controller may then dynamically rearrange channel assignments to increase system performance in the presence of the interference. Such an adjustment could result in adjacent lightweight access points being on the same channel, but this setup is preferable to having the access points remain on a channel that is unusable due to an interfering foreign access point.

  In addition, if other wireless networks are present, the controller shifts the usage of channels to complement the other networks. For example, if one network is on channel 6, an adjacent wireless LAN is assigned to channel 1 or 11. This arrangement increases the capacity of the network by limiting the sharing of frequencies. If a channel has virtually no capacity remaining, the controller may choose to avoid this channel. In very dense deployments in which all non-overlapping channels are occupied, the controller does its best, but you must consider RF density when setting expectations.
- **Utilization**—When utilization monitoring is enabled, capacity calculations can consider that some access points are deployed in ways that carry more traffic than other access points (for example, a lobby versus an engineering area). The controller can then assign channels to improve the access point with the worst performance (and therefore utilization) reported.
- **Load**—Load is taken into account when changing the channel structure to minimize the impact on clients currently in the wireless LAN. This metric keeps track of every access point's transmitted and received packet counts to determine how busy the access points are. New clients avoid an overloaded access point and associate to a new access point.

The controller combines this RF characteristic information with RRM algorithms to make system-wide decisions. Conflicting demands are resolved using soft-decision metrics that guarantee the best choice for minimizing network interference. The end result is optimal channel configuration in a three-dimensional space, where access points on the floor above and below play a major factor in an overall wireless LAN configuration.

Dynamic Transmit Power Control

The controller dynamically controls access point transmit power based on real-time wireless LAN conditions. Normally, power can be kept low to gain extra capacity and reduce interference. The controller attempts to balance access points such that they see their fourth strongest neighbor at an optimal –65 dbm or better.

The transmit power control algorithm only reduces an access point's power. However, the coverage hole algorithm, explained below, can increase access point power, thereby filling a coverage hole. For example, if a failed access point is detected, the coverage hole algorithm can automatically increase power on surrounding access points to fill the gap created by the loss in coverage.

Note See Step 5 on page 9-25 for an explanation of the transmit power levels.

Coverage Hole Detection and Correction

RRM's coverage hole detection feature can alert you to the need for an additional (or relocated) lightweight access point. If clients on a lightweight access point are detected at signal-to-noise ratio (SNR) levels that are lower than the thresholds specified in the Auto RF configuration, the access point sends a "coverage hole" alert to the controller. The alert indicates the existence of an area where clients are continually experiencing poor signal coverage, without having a viable access point to which to roam. The administrator can look up the historical record of access points to see if these alerts are chronic, indicating the existence of a persistent coverage hole as opposed to an isolated problem.

Client and Network Load Balancing

RRM load-balances new clients across grouped lightweight access points reporting to each controller. This function is particularly important when many clients converge in one spot (such as a conference room or auditorium) because RRM can automatically force some subscribers to associate with nearby access points, allowing higher throughput for all clients. The controller provides a centralized view of client loads on all access points. This information can be used to influence where new clients attach to the network or to direct existing clients to new access points to improve wireless LAN performance. The result is an even distribution of capacity across an entire wireless network.

Note Client load balancing works only for a single controller. It is not operate in a multi-controller environment.

RRM Benefits

RRM produces a network with optimal capacity, performance, and reliability while enabling you to avoid the cost of laborious historical data interpretation and individual lightweight access point reconfiguration. It also frees you from having to continually monitor the network for noise and interference problems, which can be transient and difficult to troubleshoot. Finally, RRM ensures that clients enjoy a seamless, trouble-free connection throughout the Cisco unified wireless network.

RRM uses separate monitoring and control for each deployed network: 802.11a and 802.11b/g. That is, the RRM algorithms run separately for each radio type (802.11a and 802.11b/g). RRM uses both measurements and algorithms. RRM measurements can be adjusted using the monitor intervals specified in Table 9-1, but they cannot be disabled. RRM algorithms, on the other hand, are enabled automatically but can be disabled by statically configuring channel and power assignment. The RRM algorithms run at a specified updated interval, which is 600 seconds by default.

Note RRM measurements are postponed on a per access point basis where traffic remains in the platinum QoS queue, if there was voice traffic in the last 100 ms.

Note RRM operates only with access points that use omnidirectional antennas.

Overview of RF Groups

An *RF group*, also known as an *RF domain*, is a cluster of controllers that coordinates its dynamic RRM calculations on a per 802.11-network basis. An RF group exists for each 802.11 network type. Clustering controllers into RF groups enables the RRM algorithms to scale beyond a single controller.

Lightweight access points periodically send out neighbor messages over the air. The RRM algorithms use a shared secret that is configured on the controller and sent to each access point. Access points sharing the same secret are able to validate messages from each other. When access points on different controllers hear validated neighbor messages at a signal strength of –80 dBm or stronger, the controllers dynamically form an RF group.

Note *RF groups* and *mobility groups* are similar in that they both define clusters of controllers, but they are different in terms of their use. These two concepts are often confused because the mobility group name and RF group name are configured to be the same in the Startup Wizard. Most of the time, all of the controllers in an RF group are also in the same mobility group and vice versa. However, an RF group facilitates scalable, system-wide dynamic RF management while a mobility group facilitates scalable, system-wide mobility and controller redundancy. Refer to Chapter 10 for more information on mobility groups.

RF Group Leader

The members of an RF group elect an RF group leader to maintain a “master” power and channel scheme for the group. The RF group leader is dynamically chosen and cannot be selected by the user. In addition, the RF group leader can change at any time, depending on the RRM algorithm calculations.

The *RF group leader* analyzes real-time radio data collected by the system and calculates the master power and channel plan. The RRM algorithms try to optimize around a signal strength of –65 dBm between all access points and to avoid 802.11 co-channel interference and contention as well as non-802.11 interference. The RRM algorithms employ dampening calculations to minimize system-wide dynamic changes. The end result is dynamically calculated optimal power and channel planning that is responsive to an always changing RF environment.

The RRM algorithms run at a specified updated interval, which is 600 seconds by default. Between update intervals, the RF group leader sends keep-alive messages to each of the RF group members and collects real-time RF data.

Note Several monitoring intervals are also available. See Table 9-1 for details.

RF Group Name

A controller is configured with an *RF group name*, which is sent to all access points joined to the controller and used by the access points as the shared secret for generating the hashed MIC in the neighbor messages. To create an RF group, you simply configure all of the controllers to be included in the group with the same RF group name. You can include up to 20 controllers and 1000 access points in an RF group.

If there is any possibility that an access point joined to a controller may hear RF transmissions from an access point on a different controller, the controllers should be configured with the same RF group name. If RF transmissions between access points can be heard, then system-wide RRM is recommended to avoid 802.11 interference and contention as much as possible.

Configuring an RF Group

This section provides instructions for configuring RF groups through either the GUI or the CLI.

Note The RF group name is generally set at deployment time through the Startup Wizard. However, you can change it as necessary.

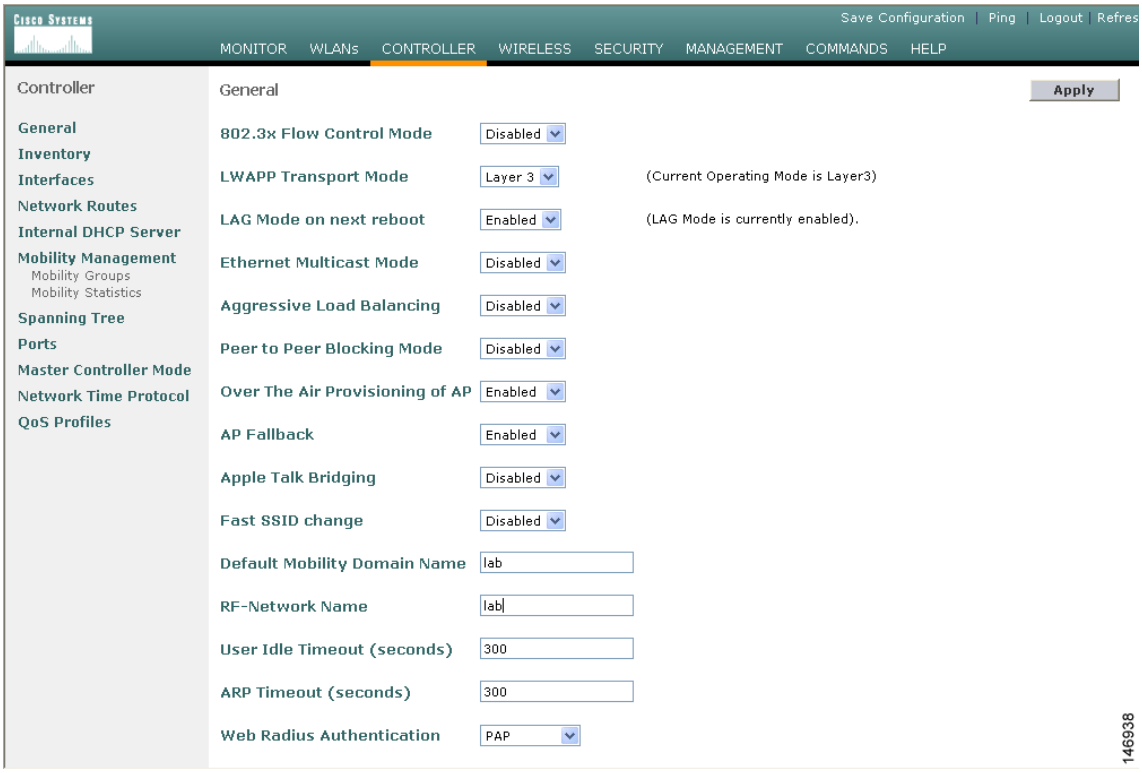
Note You can also configure RF groups using the Cisco Wireless Control System (WCS). Refer to the *Cisco Wireless Control System Configuration Guide* for instructions.

Using the GUI to Configure an RF Group

Follow these steps to create an RF group using the GUI.

Step 1 Click **Controller > General** to access the General page (see Figure 9-1).

Figure 9-1 General Page



Step 2 Enter a name for the RF group in the RF-Network Name field. The name can contain up to 19 ASCII characters.

Step 3 Click **Save Configuration** to save your changes.

Step 4 Repeat this procedure for each controller that you want to include in the RF group.

Using the CLI to Configure RF Groups

Follow these steps to configure an RF group using the CLI.

Step 1 Enter **config network rf-network-name** *name* to create an RF group.

Note Enter up to 19 ASCII characters for the group name.

Step 2 Enter **show network** to view the RF group.

Step 3 Repeat this procedure for each controller that you want to include in the RF group.

Viewing RF Group Status

This section provides instructions for viewing the status of the RF group through either the GUI or the CLI.

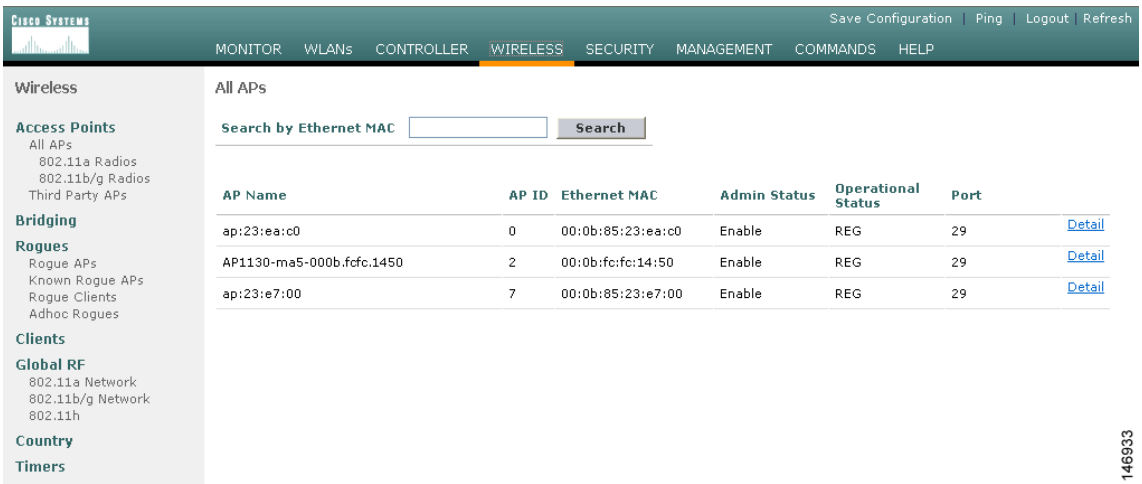
Note You can also view the status of RF groups using the Cisco Wireless Control System (WCS). Refer to the *Cisco Wireless Control System Configuration Guide* for instructions.

Using the GUI to View RF Group Status

Follow these steps to view the status of the RF group using the GUI.

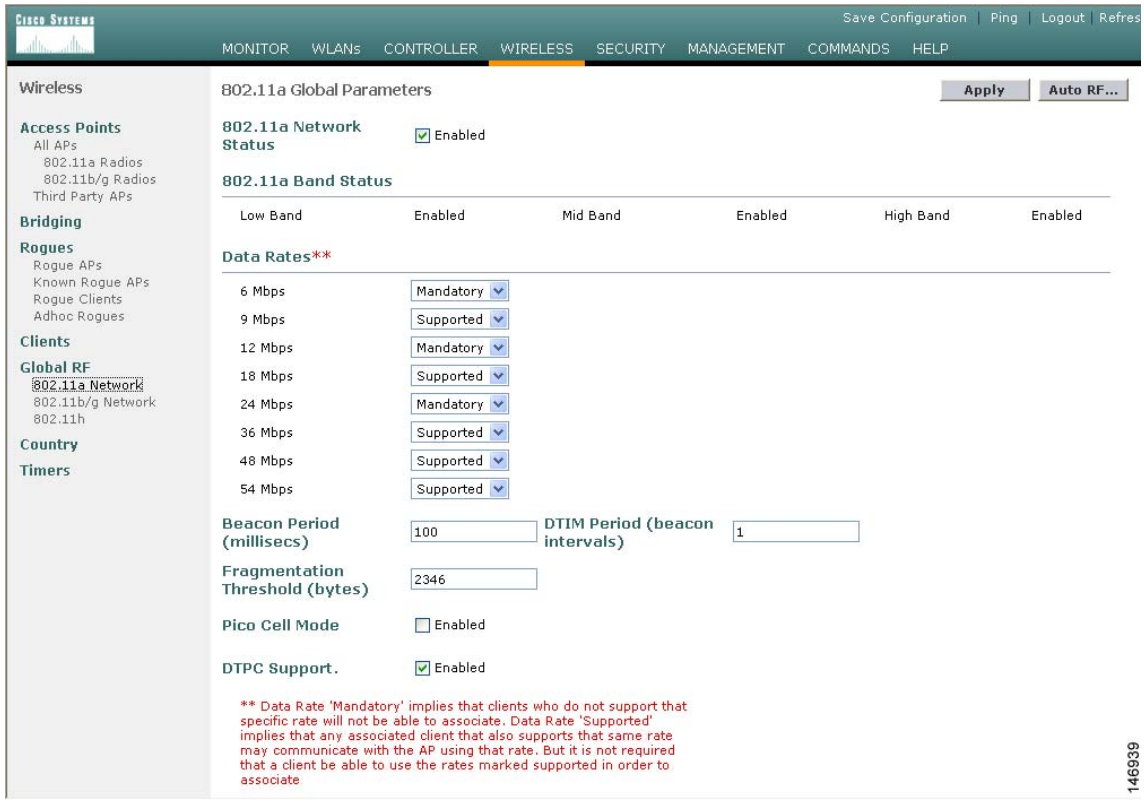
Step 1 Click **Wireless** to access the All APs page (see Figure 9-2).

Figure 9-2 All APs Page



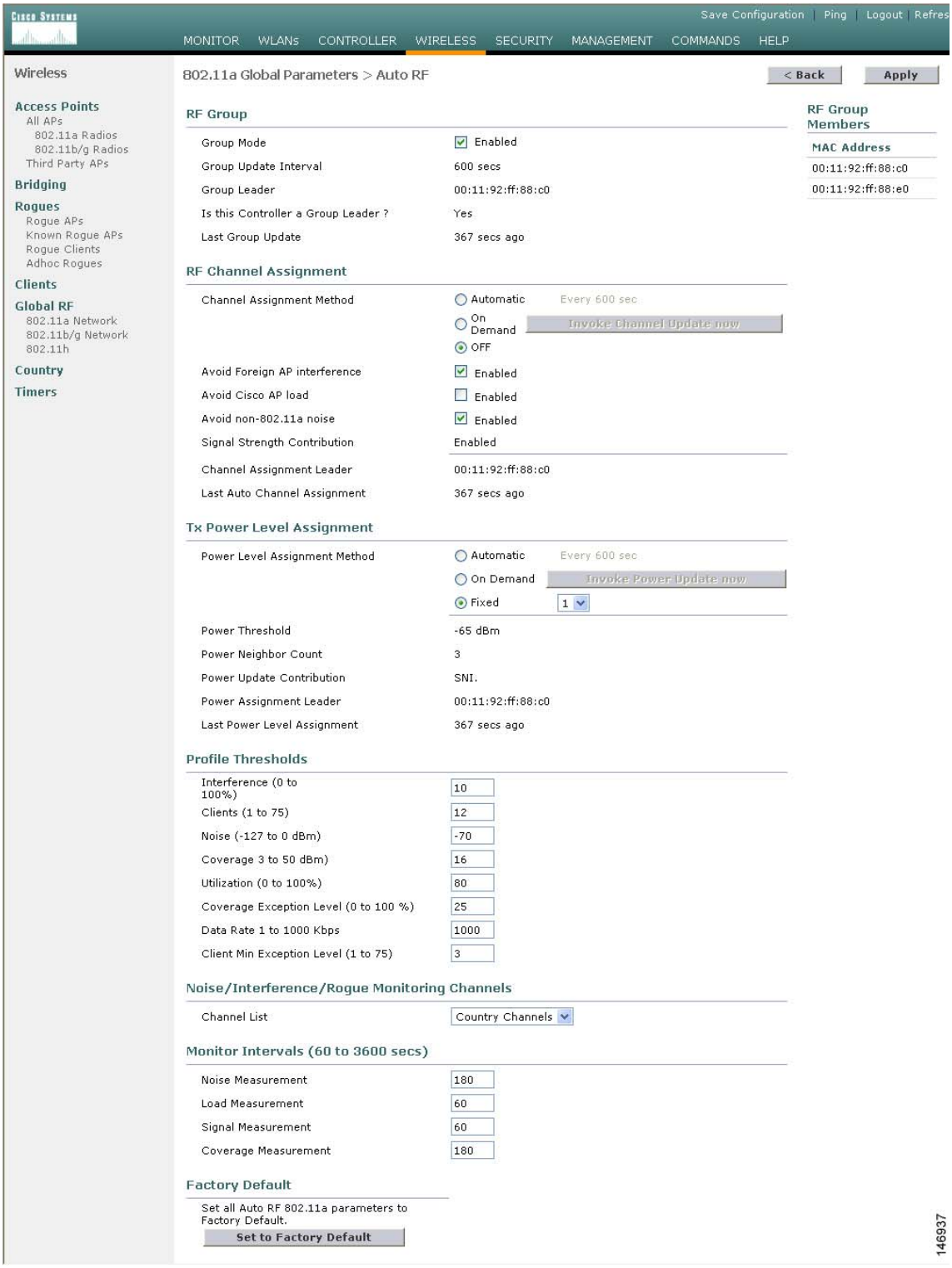
Step 2 Under Global RF, click either **802.11a Network** or **802.11b/g Network** to access the Global Parameters page (see Figure 9-3).

Figure 9-3 Global Parameters Page



Step 3 Click **Auto RF** to access the Global Parameters > Auto RF page (see Figure 9-4).

Figure 9-4 Global Parameters > Auto RF Page



The top of this page shows the details of the RF group, specifically how often the group information is updated (600 seconds by default), the MAC address of the RF group leader, whether this particular controller is the group leader, the last time the group information was updated, and the MAC addresses of all group members.

Note Automatic RF grouping, which is set through the **Group Mode** check box, is enabled by default. See Table 9-1 for more information on this parameter.

Step 4 If desired, repeat this procedure for the network type you did not select (802.11a or 802.11b/g).

Using the CLI to View RF Group Status

Follow these steps to view the status of the RF group using the CLI.

Step 1 Enter **show advanced 802.11a group** to see which controller is the RF group leader for the 802.11a RF network. Information similar to the following appears:

```
Radio RF Grouping
      802.11a Group Mode.............................. AUTO
      802.11a Group Update Interval................... 600 seconds
      802.11a Group Leader............................ 00:16:9d:ca:d9:60
      802.11a Group Member............................ 00:16:9d:ca:d9:60
      802.11a Last Run............................... 594 seconds ago
```

This text shows the details of the RF group, specifically whether automatic RF grouping is enabled for this controller, how often the group information is updated (600 seconds by default), the MAC address of the RF group leader, the MAC address of this particular controller, and the last time the group information was updated.

Note If the MAC addresses of the group leader and the group member are identical, this controller is currently the group leader.

Step 2 Enter **show advanced 802.11b group** to see which controller is the RF group leader for the 802.11b/g RF network.

Enabling Rogue Access Point Detection

After you have created an RF group of controllers, you need to configure the access points connected to the controllers to detect rogue access points. The access points will then check the beacon/probe-response frames in neighboring access point messages to see if they contain an authentication information element (IE) that matches that of the RF group. If the check is successful, the frames are authenticated. Otherwise, the authorized access point reports the neighboring access point as a rogue, records its BSSID in a rogue table, and sends the table to the controller.

Using the GUI to Enable Rogue Access Point Detection

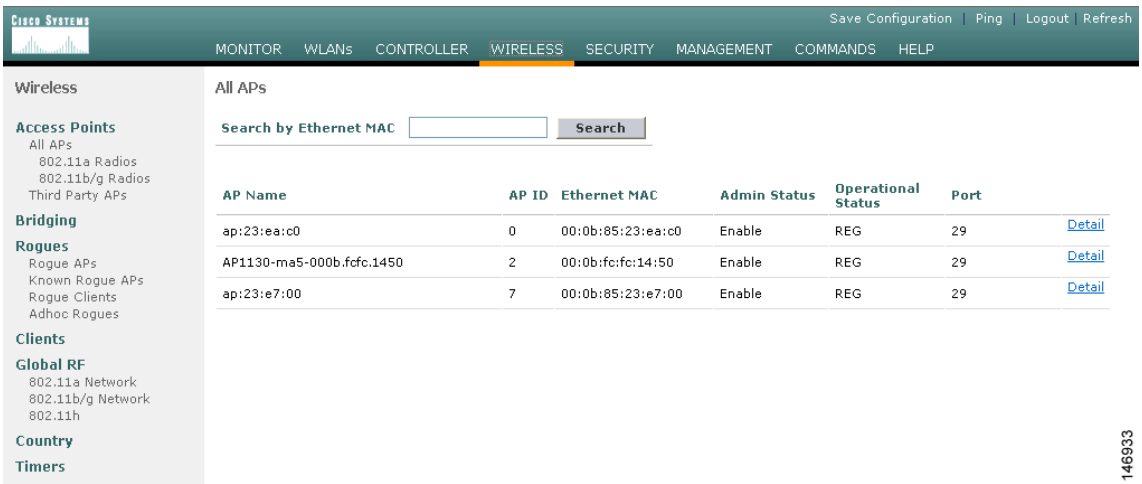
Follow these steps to enable rogue access point detection using the GUI.

Step 1 Make sure that each controller in the RF group has been configured with the same RF group name.

Note The name is used to verify the authentication IE in all beacon frames. If the controllers have different names, false alarms will occur.

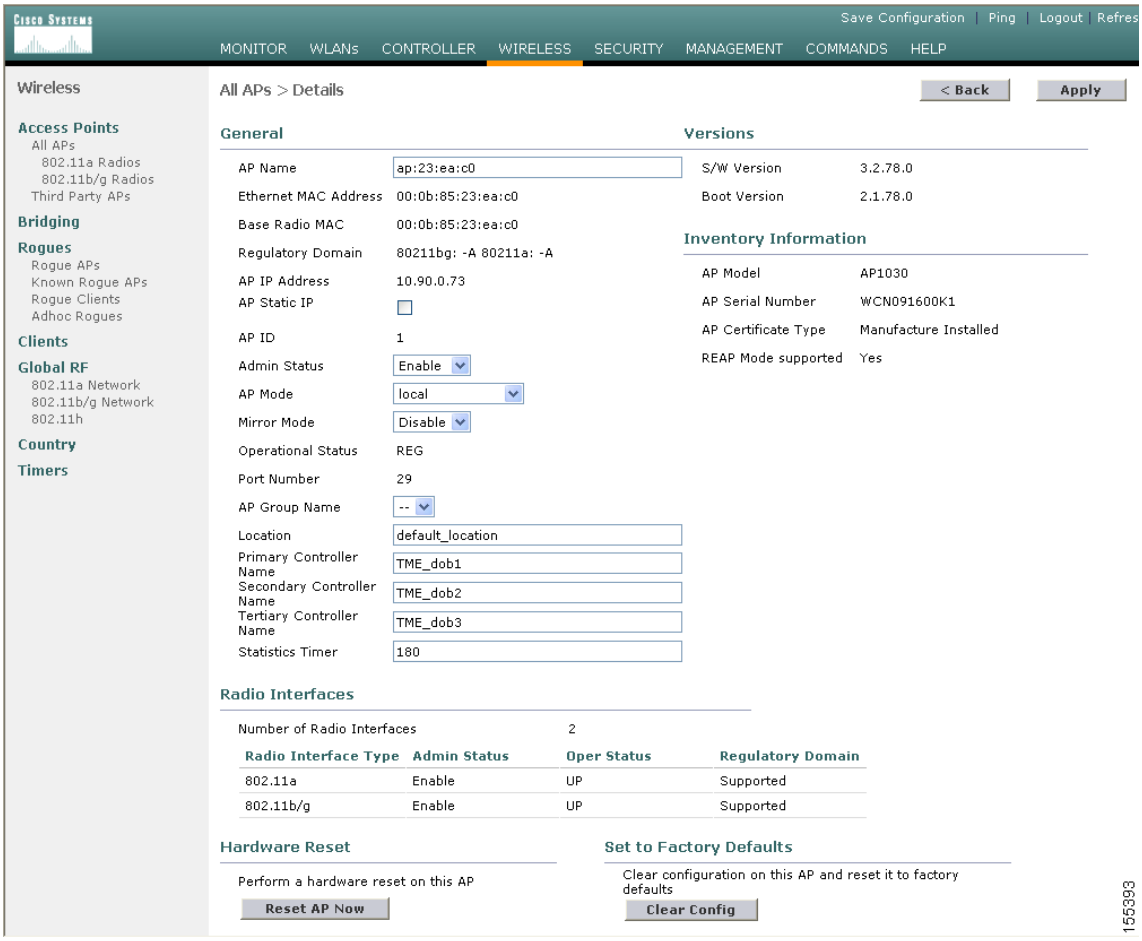
Step 2 Click **Wireless** to access the All APs page (see Figure 9-5).

Figure 9-5 All APs Page



Step 3 Click the **Detail** link for an access point to access the All APs > Details page (see Figure 9-6).

Figure 9-6 All APs > Details Page

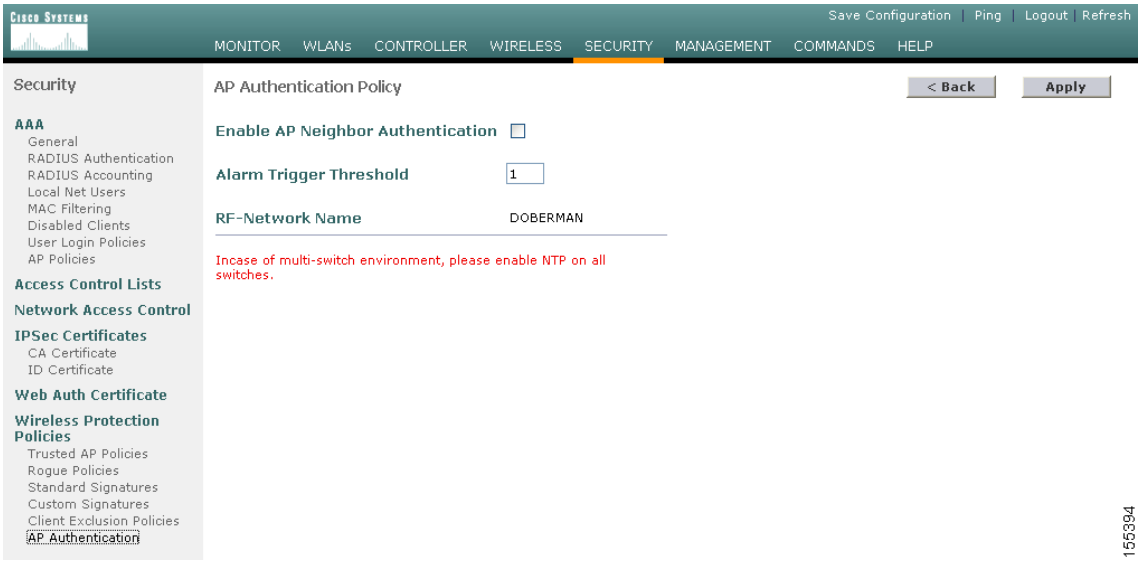


Step 4 Choose either **local** or **monitor** from the AP Mode drop-down box and click **Save Configuration** to save your changes.

Step 5 Repeat Step 2 through Step 4 for every access point connected to the controller.

Step 6 Click **Security > AP Authentication** (under Wireless Protection Policies) to access the AP Authentication Policy page (see Figure 9-7).

Figure 9-7 AP Authentication Policy Page



The name of the RF group to which this controller belongs appears at the bottom of the page.

Step 7 Check the **Enable AP Neighbor Authentication** check box to enable rogue access point detection.

Step 8 Enter a number in the Alarm Trigger Threshold edit box to specify when a rogue access point alarm is generated. An alarm occurs when the threshold value (which specifies the number of access point frames with an invalid authentication IE) is met or exceeded within the detection period.

Note The valid threshold range is from1 to 255, and the default threshold value is 1. To avoid false alarms, you may want to set the threshold to a higher value.

Step 9 Click **Save Configuration** to save your changes.

Step 10 Repeat Step 2 through Step 9 on every controller in the RF group.

Note If rogue access point detection is not enabled on every controller in the RF group, the access points on the controllers with this feature disabled are reported as rogues.

Using the CLI to Enable Rogue Access Point Detection

Follow these steps to enable rogue access point detection using the CLI.

Step 1 Make sure that each controller in the RF group has been configured with the same RF group name.

Note The name is used to verify the authentication IE in all beacon frames. If the controllers have different names, false alarms will occur.

Step 2 Enter **config ap mode local** *Cisco_AP* or **config ap mode monitor** *Cisco_AP* to configure this particular access point for local (normal) mode or monitor (listen-only) mode.

Step 3 Repeat Step 2 for every access point connected to the controller.

Step 4 Enter **config wps ap-authentication** to enable rogue access point detection.

Step 5 Enter **config wps ap-authentication** *threshold* to specify when a rogue access point alarm is generated. An alarm occurs when the threshold value (which specifies the number of access point frames with an invalid authentication IE) is met or exceeded within the detection period.

Note The valid threshold range is from1 to 255, and the default threshold value is 1. To avoid false alarms, you may want to set the threshold to a higher value.

Step 6 Repeat Step 4 and Step 5 on every controller in the RF group.

Note If rogue access point detection is not enabled on every controller in the RF group, the access points on the controllers with this feature disabled are reported as rogues.

Configuring Dynamic RRM

The controller is preconfigured with factory default RRM settings designed to optimize radio performance. However, you can modify the controller's dynamic RRM configuration parameters at any time through either the GUI or the CLI.

Note You can configure these parameters on an individual controller that is not part of an RF group or on RF group members.

Note The RRM parameters should be set to the same values on every controller in an RF group. The RF group leader can change at any time. If the RRM parameters are not identical for all RF group members, varying results can occur when the group leader changes.

Using the GUI to Configure Dynamic RRM

Follow these steps to configure dynamic RRM parameters using the GUI.

Step 1 Access the Global Parameters > Auto RF page (see Figure 9-4).

Note Click **Set to Factory Default** at the bottom of the page if you want to return all of the controller's RRM parameters to their factory default values.

Step 2 Table 9-1 lists and describes the configurable RRM parameters. Follow the instructions in the table to make any desired changes.

Table 9-1 RRM Parameters

Parameter	Description
RF Group	
Group Mode	Determines whether the controller participates in an RF group. **Options:** Enabled or Disabled **Default:** Enabled

Group Mode	Description
Enabled	The controller automatically forms an RF group with other controllers. The group dynamically elects a leader to optimize RRM parameter settings for the group.
Disabled	The controller does not participate in automatic RF grouping. Rather, it optimizes its own access point parameters.

Note Cisco recommends that controllers participate in automatic RF grouping. However, you can disable this feature if necessary by unchecking the check box. Note also, however, that you override dynamic RRM settings without disabling automatic RF group participation. See the "Overriding Dynamic RRM" section on page 9-23 for instructions.

Table 9-1 RRM Parameters (continued)

<table>
<tr><th>Parameter</th><th>Description</th></tr>
<tr><td colspan="2">RF Channel Assignment</td></tr>
<tr><td>Channel Assignment Method</td><td>The controller's dynamic channel assignment mode.
Options: Automatic, On Demand, or Off
Default: Automatic

<table>
<tr><th>Channel Assignment Method</th><th>Description</th></tr>
<tr><td>Automatic</td><td>Causes the controller to periodically evaluate and, if necessary, update the channel assignment for all joined access points.</td></tr>
<tr><td>On Demand</td><td>Causes the controller to periodically evaluate the channel assignment for all joined access points. However, the controller reassigns channels, if necessary, only when you click Invoke Channel Update Now.
Note The controller does not evaluate and update the channel immediately after you click Invoke Channel Update Now. It waits for the next interval (default is 600 seconds).</td></tr>
<tr><td>Off</td><td>Prevents the controller from evaluating and, if necessary, updating the channel assignment for joined access points.</td></tr>
</table>
Note For optimal performance, Cisco recommends that you use the Automatic setting. Refer to the "Disabling Dynamic Channel and Power Assignment Globally for a Controller" section on page 9-27 for instructions if you ever need to disable the controller's dynamic settings.</td></tr>
<tr><td>Avoid Foreign AP Interference</td><td>Causes the controller's RRM algorithms to consider 802.11 traffic from foreign access points (those not included in your wireless network) when assigning channels to lightweight access points. For example, RRM may adjust the channel assignment to have access points avoid channels close to foreign access points.
Options: Enabled or Disabled
Default: Enabled</td></tr>
</table>

Table 9-1 RRM Parameters (continued)

Parameter	Description
Avoid Cisco AP Load	Causes the controller's RRM algorithms to consider 802.11 traffic from Cisco lightweight access points in your wireless network when assigning channels. For example, RRM can assign better reuse patterns to access points that carry a heavier traffic load. **Options:** Enabled or Disabled **Default:** Disabled
Avoid Non-802.11a (802.11b) Noise	Causes the controller's RRM algorithms to consider noise (non-802.11 traffic) in the channel when assigning channels to lightweight access points. For example, RRM may have access points avoid channels with significant interference from non-access point sources, such as microwave ovens. **Options:** Enabled or Disabled **Default:** Enabled

The following non-configurable RF channel parameter settings are also shown:

- **Signal Strength Contribution**—This parameter is always enabled. RRM constantly monitors the relative location of all access points within the RF group to ensure near-optimal channel reuse.
- **Channel Assignment Leader**—The MAC address of the RF group leader, which is responsible for channel assignment.
- **Last Auto Channel Assignment**—The last time RRM evaluated the current channel assignments.

Table 9-1 RRM Parameters (continued)

<table>
<tr><th>Parameter</th><th>Description</th></tr>
<tr><td colspan="2">Tx Power Level Assignment</td></tr>
<tr><td>Power Level Assignment Method</td><td>The controller's dynamic power assignment mode.
Options: Automatic, On Demand, or Fixed
Default: Automatic

<table>
<tr><th>Power Level Assignment Method</th><th>Description</th></tr>
<tr><td>Automatic</td><td>Causes the controller to periodically evaluate and, if necessary, update the transmit power for all joined access points.</td></tr>
<tr><td>On Demand</td><td>Causes the controller to periodically evaluate the transmit power for all joined access points. However, the controller updates the power, if necessary, only when you click Invoke Power Update Now.
Note The controller does not evaluate and update the transmit power immediately after you click Invoke Power Update Now. It waits for the next interval (default is 600 seconds).</td></tr>
<tr><td>Fixed</td><td>Prevents the controller from evaluating and, if necessary, updating the transmit power for joined access points. The power level is set to the fixed value chosen from the drop-down box.
Note The transmit power level is assigned an integer value instead of a value in mW or dBm. The integer corresponds to a power level that varies depending on the regulatory domain in which the access points are deployed. See Step 5 on page 9-25 for information on available transmit power levels.</td></tr>
</table>
Note For optimal performance, Cisco recommends that you use the Automatic setting. Refer to the "Disabling Dynamic Channel and Power Assignment Globally for a Controller" section on page 9-27 for instructions if you ever need to disable the controller's dynamic settings.</td></tr>
</table>

Table 9-1 RRM Parameters (continued)

Parameter	Description
The following non-configurable transmit power level parameter settings are also shown: • **Power Threshold** and **Power Neighbor Count—**These parameters are used to fine tune the power control. The objective is to limit power so that at most the *neighbor count* access points receive the signal of each access point above a *power threshold*. • **Power Update Contribution**—The factors used for changing power assignment levels: load (L), signal (S), noise (N), or interference (I). • **Power Assignment Leader**—The MAC address of the RF group leader, which is responsible for power level assignment. • **Last Power Level Assignment**—The last time RRM evaluated the current transmit power level assignments.	
Profile Thresholds—Lightweight access points send an SNMP *trap* (or an *alert*) to the controller when the values set for these threshold parameters are exceeded. The controller's RRM software uses this information to evaluate the integrity of the entire network and makes adjustments accordingly.	
Interference (0 to 100%)	The percentage of interference (802.11 traffic from sources outside of your wireless network) on a single access point. **Default:** 10%
Clients (1 to 75)	The number of clients on a single access point. **Default:** 12
Noise (–127 to 0 dBm)	The level of noise (non-802.11 traffic) on a single access point. **Default:** –70 dBm
Coverage (3 to 50 dB)	The signal-to-noise ratio (SNR) per access point. This value is also used for reporting detected coverage holes. **Default:** 12 dB (802.11b/g) or 16 dB (802.11a)
Utilization (0 to 100%)	The percentage of RF bandwidth being used by a single access point. **Default:** 80%
Coverage Exception Level (0 to 100%)	The percentage of clients on an access point that are experiencing a low signal level but cannot roam to another access point. This value is based on the Coverage threshold and the Client Min Exception Level threshold. **Default:** 25%
Data Rate (1 to 1000 Kbps)	The rate at which a single access point transmits or receives data packets. **Default:** 1000 Kbps

Table 9-1 RRM Parameters (continued)

<table>
<tr><th>Parameter</th><th colspan="2">Description</th></tr>
<tr><td>Client Min Exception Level (1 to 75)</td><td colspan="2">The minimum number of clients on an access point with a signal-to-noise ratio (SNR) below the Coverage threshold. This threshold works in conjunction with the Coverage and Coverage Exception Level thresholds. A coverage exception is alerted if the Coverage Exception Level percentage of clients (25%) and the Client Min Exception Level number of clients (3) fall below the Coverage threshold (12 dB). In this example, a coverage alarm would be generated if at least 25% and a minimum of 3 clients have an SNR value below 12 dB (802.11b/g) or 16 dB (802.11a).
Default: 3</td></tr>
<tr><td colspan="3">Noise/Interference/Rogue Monitoring Channels</td></tr>
<tr><td>Channel List</td><td colspan="2">The set of channels that the access point uses for RRM scanning.
Options: All Channels, Country Channels, or DCA Channels
Default: Country Channels</td></tr>
<tr><td></td><td>Channel List</td><td>Description</td></tr>
<tr><td></td><td>All Channels</td><td>RRM channel scanning occurs on all channels supported by the selected radio, which includes channels not allowed in the country of operation.</td></tr>
<tr><td></td><td>Country Channels</td><td>RRM channel scanning occurs only on the data channels in the country of operation.</td></tr>
<tr><td></td><td>DCA Channels</td><td>RRM channel scanning occurs only on the channel set used by the Dynamic Channel Allocation (DCA) algorithm, which typically includes all the non-overlapping channels allowed in the country of operation.</td></tr>
<tr><td colspan="3">Monitor Intervals</td></tr>
<tr><td>Noise Measurement</td><td colspan="2">How frequently the access point measures noise and interference.
Range: 60 to 3600 seconds
Default: 180 seconds</td></tr>
<tr><td>Load Measurement</td><td colspan="2">How frequently the access point measures 802.11 traffic.
Range: 60 to 3600 seconds
Default: 60 seconds</td></tr>
</table>

Table 9-1 RRM Parameters (continued)

Parameter	Description
Signal Measurement	How frequently the access point measures signal strength and how frequently neighbor packets (messages) are sent, which eventually builds the neighbor list. **Range:** 60 to 3600 seconds **Default:** 60 seconds
Coverage Measurement	How frequently the access point measures the coverage area and passes this information to the controller. **Range:** 60 to 3600 seconds **Default:** 180 seconds

Step 3 Click **Save Configuration** to save your changes.

Step 4 Repeat this procedure to set the same parameter values for every controller in the RF group.

Using the CLI to Configure Dynamic RRM

Follow these steps to configure dynamic RRM using the CLI.

Step 1 Enter one of these commands to disable the 802.11a or 802.11b/g network:

- **config 802.11a disable**
- **config 802.11b disable**

Step 2 Perform one of the following:

- To have RRM automatically configure all 802.11a or 802.11b/g channels based on availability and interference, enter one of these commands:
  - **config 802.11a channel global auto**
  - **config 802.11b channel global auto**
- To have RRM automatically reconfigure all 802.11a or 802.11b/g channels one time based on availability and interference, enter one of these commands:
  - **config 802.11a channel global once**
  - **config 802.11b channel global once**

Step 3 Perform one of the following:

- To have RRM automatically set the transmit power for all 802.11a or 802.11b/g radios at periodic intervals, enter one of these commands:
  - **config 802.11a txPower global auto**
  - **config 802.11b txPower global auto**
- To have RRM automatically reset the transmit power for all 802.11a or 802.11b/g radios one time, enter one of these commands:
  - **config 802.11a txPower global once**
  - **config 802.11b txPower global once**

Step 4 Enter one of these commands to enable the 802.11a or 802.11b/g network:

- **config 802.11a enable**
- **config 802.11b enable** (To enable the 802.11g network, enter **config 802.11b 11gSupport enable** after the **config 802.11b enable** command.)

Overriding Dynamic RRM

In some deployments, it is desirable to statically assign channel and transmit power settings to the access points instead of relying on the dynamic RRM algorithms provided by Cisco. Typically, this is true in challenging RF environments and non-standard deployments but not the more typical carpeted offices.

Note If you choose to statically assign channels and power levels to your access points and/or to disable dynamic channel and power assignment, you should still use automatic RF grouping to avoid spurious rogue device events.

You can disable dynamic channel and power assignment globally for a controller, or you can leave dynamic channel and power assignment enabled and statically configure specific access point radios with a channel and power setting. Follow the instructions in one of the following sections:

- Statically Assigning Channel and Transmit Power Settings to Access Point Radios, page 9-24
- Disabling Dynamic Channel and Power Assignment Globally for a Controller, page 9-27

Note While you can specify a global default transmit power parameter for each network type that applies to all the access point radios on a controller, you must set the channel for each access point radio when you disable dynamic channel assignment. You may also want to set the transmit power for each access point instead of leaving the global transmit power in effect.

Note You can also override dynamic RRM using the Cisco Wireless Control System (WCS). Refer to the *Cisco Wireless Control System Configuration Guide* for instructions.

Statically Assigning Channel and Transmit Power Settings to Access Point Radios

This section provides instructions for statically assigning channel and power settings using the GUI or CLI.

Note Cisco recommends that you assign different nonoverlapping channels to access points that are within close proximity to each other. The nonoverlapping channels in the U.S. are 36, 40, 44, 48, 52, 56, 60, 64, 149, 153, 157, and 161 in an 802.11a network and 1, 6, and 11 in an 802.11b/g network.

Note Cisco recommends that you do not assign all access points that are within close proximity to each other to the maximum power level.

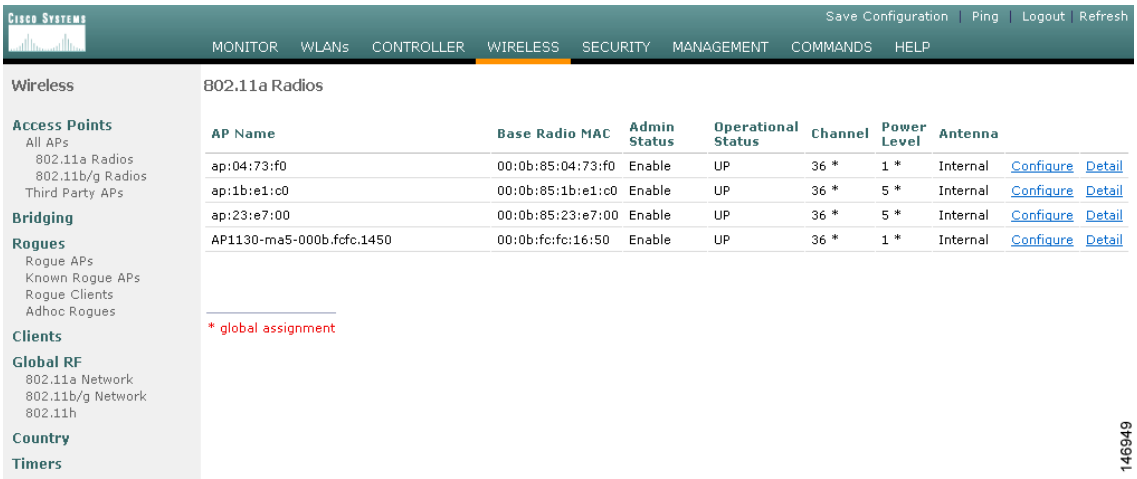
Using the GUI to Statically Assign Channel and Transmit Power Settings

Follow these steps to statically assign channel and/or power settings on a per access point radio basis using the GUI.

Step 1 Click **Wireless** to access the All APs page (see Figure 9-2).

Step 2 Under Access Points, click either **802.11a Radios** or **802.11b/g Radios** to access the Radios page (see Figure 9-8).

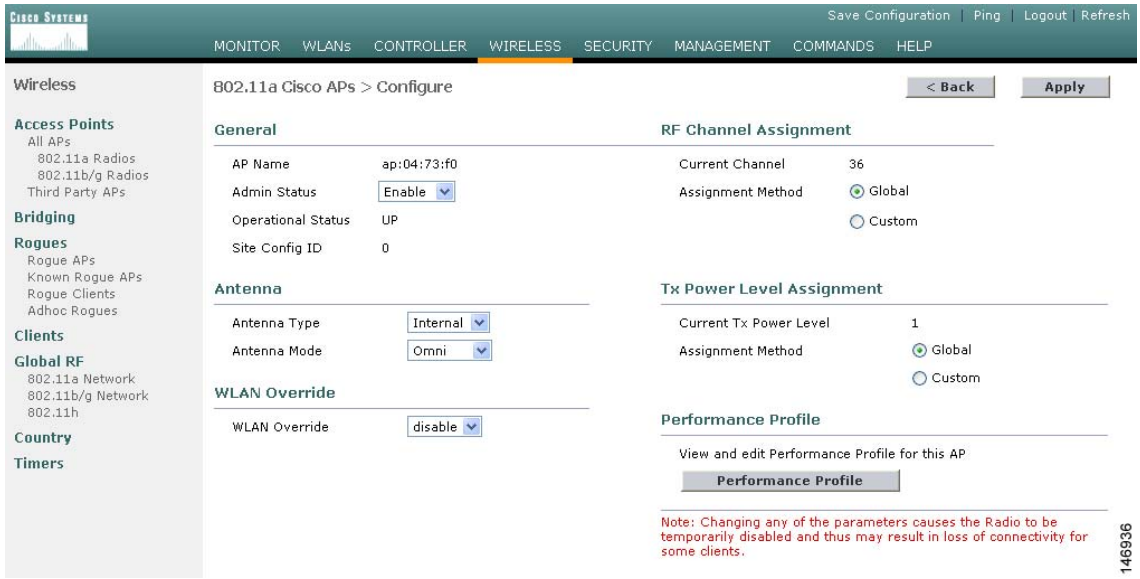
Figure 9-8 Radios Page



This page shows all the 802.11a or 802.11b/g access point radios that are joined to the controller and their current settings.

Step 3 Click **Configure** for the access point for which you want to modify the radio configuration. The Cisco APs > Configure page appears (see Figure 9-9).

Figure 9-9 Cisco APs > Configure Page



Step 4 To assign an RF channel to the access point radio, choose **Custom** for the Assignment Method under RF Channel Assignment and choose a channel from the drop-down box.

Step 5 To assign a transmit power level to the access point radio, choose **Custom** for the Assignment Method under Tx Power Level Assignment and choose a transmit power level from the drop-down box.

The transmit power level is assigned an integer value instead of a value in mW or dBm. The integer corresponds to a power level that varies depending on the regulatory domain in which the access points are deployed. The number of available power levels varies based on the access point model. However, power level 1 is always the maximum power level allowed per country code setting, with each successive power level representing 50% of the previous power level. For example, 1 = maximum power level in a particular regulatory domain, 2 = 50% power, 3 = 25% power, 4 = 12.5% power, and so on.

Note Refer to the Hardware Installation Guide for your access point for the maximum transmit power levels supported per regulatory domain. Also, refer to the data sheet for your access point for the number of power levels supported.

Step 6 Click **Save Configuration** to save the changes to the access point radio.

Step 7 Repeat this procedure for each access point radio for which you want to assign a static channel and power level.

Using the CLI to Statically Assign Channel and Transmit Power Settings

Follow these steps to statically assign channel and/or power settings on a per access point radio basis using the CLI.

Step 1 Enter one of these commands to disable the 802.11a or 802.11b/g network:

- **config 802.11a disable**
- **config 802.11b disable**

Step 2 To specify the channel that a particular access point is to use, enter one of these commands:

- **config 802.11a channel** *Cisco_AP channel*
- **config 802.11b channel** *Cisco_AP channel*

Example: To configure 802.11a channel 36 as the default channel on AP1, enter this command: **config 802.11a channel AP1 36**.

Step 3 To specify the transmit power level that a particular access point is to use, enter one of these commands:

- **config 802.11a txPower** *Cisco_AP power_level*
- **config 802.11b txPower** *Cisco_AP power_level*

Example: To set the transmit power for 802.11a AP1 to power level 2, enter this command: **config 802.11a txPower AP1 2**.

The transmit power level is assigned an integer value instead of a value in mW or dBm. The integer corresponds to a power level that varies depending on the regulatory domain in which the access points are deployed. The number of available power levels varies based on the access point model. However, power level 1 is always the maximum power level allowed per country code setting, with each successive power level representing 50% of the previous power level. For example, 1 = maximum power level in a particular regulatory domain, 2 = 50% power, 3 = 25% power, 4 = 12.5% power, and so on.

Note Refer to the Hardware Installation Guide for your access point for the maximum transmit power levels supported per regulatory domain. Also, refer to the data sheet for your access point for the number of power levels supported.

Step 4 Repeat Step 2 and Step 3 for each access point radio for which you want to assign a static channel and power level.

Step 5 Enter one of these commands to enable the 802.11a or 802.11b/g network:

- **config 802.11a enable**
- **config 802.11b enable** (To enable the 802.11g network, enter **config 802.11b 11gSupport enable** after the **config 802.11b enable** command.)

Disabling Dynamic Channel and Power Assignment Globally for a Controller

This section provides instructions for disabling dynamic channel and power assignment using the GUI or CLI.

Using the GUI to Disable Dynamic Channel and Power Assignment

Follow these steps to configure disable dynamic channel and power assignment using the GUI.

Step 1 Click **Wireless** to access the All APs page (see Figure 9-2).

Step 2 Under Global RF, click either **802.11a Network** or **802.11b/g Network** to access the Global Parameters page (see Figure 9-3).

Step 3 Click **Auto RF** to access the Global Parameters > Auto RF page (see Figure 9-4).

Step 4 To disable dynamic channel assignment, choose **Off** under RF Channel Assignment.

Step 5 To disable dynamic power assignment, choose **Fixed** under Tx Power Level Assignment and choose a default transmit power level from the drop-down box.

Note See Step 5 on page 9-25 for information on transmit power levels.

Step 6 Click **Save Configuration** to save your changes.

Step 7 If you are overriding the default channel and power settings on a per radio basis, assign static channel and power settings to each of the access point radios that are joined to the controller.

Step 8 If desired, repeat this procedure for the network type you did not select (802.11a or 802.11b/g).

Using the CLI to Disable Dynamic Channel and Power Assignment

Follow these steps to disable RRM for all 802.11a or 802.11b/g radios.

Step 1 Enter one of these commands to disable the 802.11a or 802.11b/g network:

- **config 802.11a disable**
- **config 802.11b disable**

Step 2 Enter one of these commands to disable RRM for all 802.11a or 802.11b/g radios and set all channels to the default value:

- **config 802.11a channel global off**
- **config 802.11b channel global off**

Step 3 Enter one of these commands to enable the 802.11a or 802.11b/g network:

- **config 802.11a enable**
- **config 802.11b enable** (To enable the 802.11g network, enter **config 802.11b 11gSupport enable** after the **config 802.11b enable command**.)

Viewing Additional RRM Settings Using the CLI

Use these commands to view additional 802.11a and 802.11b/g RRM settings:

- **show advanced 802.11a** *?*
- **show advanced 802.11b** *?*

  where *?* is one of the following:

  CCX—Shows the Cisco Compatible Extensions (CCX) RRM configuration.

  channel—Shows the channel assignment configuration and statistics.

  logging—Shows the RF event and performance logging.

  monitor—Shows the Cisco radio monitoring.

  profile—Shows the access point performance profiles.

  receiver—Shows the 802.11a or 802.11b/g receiver configuration and statistics.

  summary—Shows the configuration and statistics of the 802.11a or 802.11b/g access points

  txpower—Shows the transmit power assignment configuration and statistics.

Note To troubleshoot RRM-related issues, refer to the *Cisco Wireless LAN Controller Command Reference, Release 3.2* for RRM (airewave-director) debug commands.

CHAPTER 10

Configuring Mobility Groups

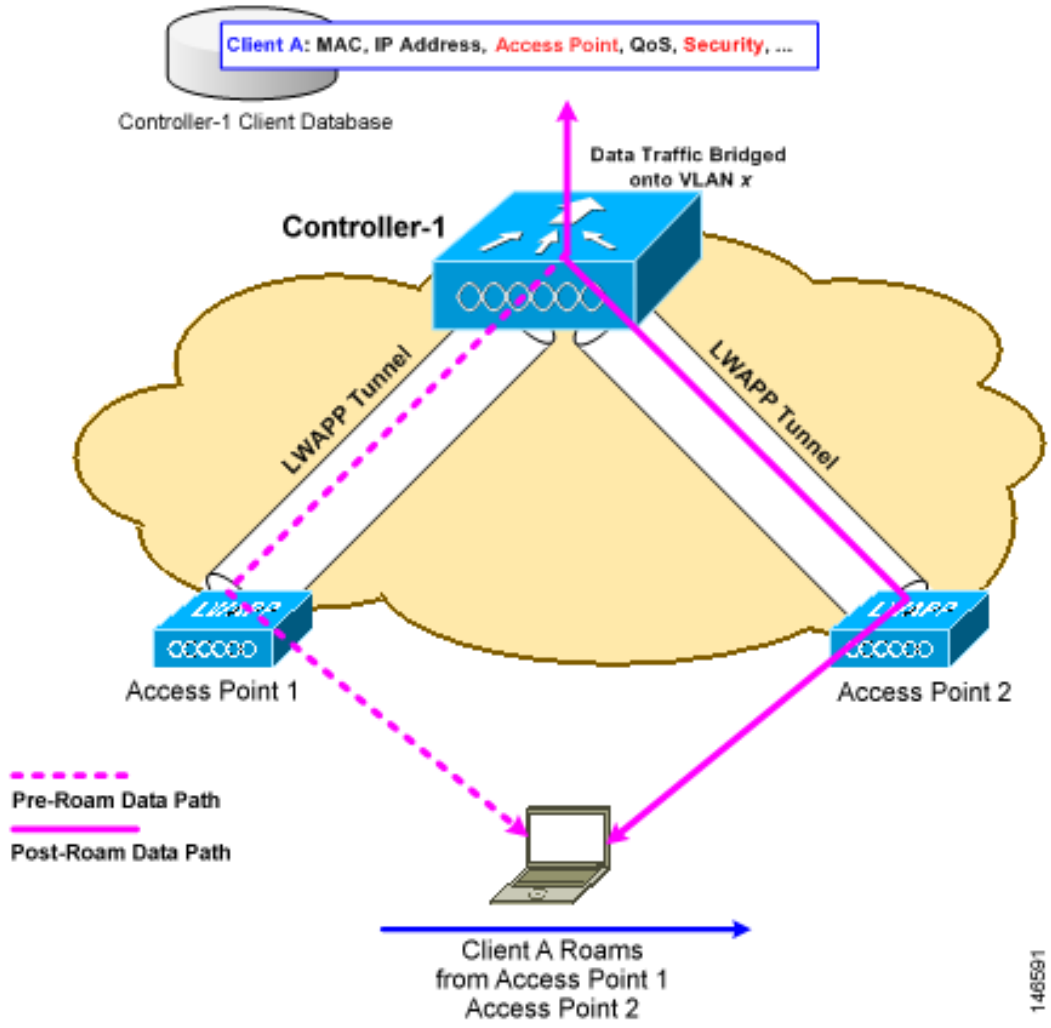
This chapter describes mobility groups and explains how to configure them on the controllers. It contains these sections:

Overview of Mobility

Mobility, or *roaming*, is a wireless LAN client's ability to maintain its association seamlessly from one access point to another securely and with as little latency as possible. This section explains how mobility works when controllers are included in a wireless network.

When a wireless client associates and authenticates to an access point, the access point's controller places an entry for that client in its client database. This entry includes the client's MAC and IP addresses, security context and associations, quality of service (QoS) contexts, the WLAN, and the associated access point. The controller uses this information to forward frames and manage traffic to and from the wireless client. Figure 10-1 illustrates a wireless client roaming from one access point to another when both access points are joined to the same controller.

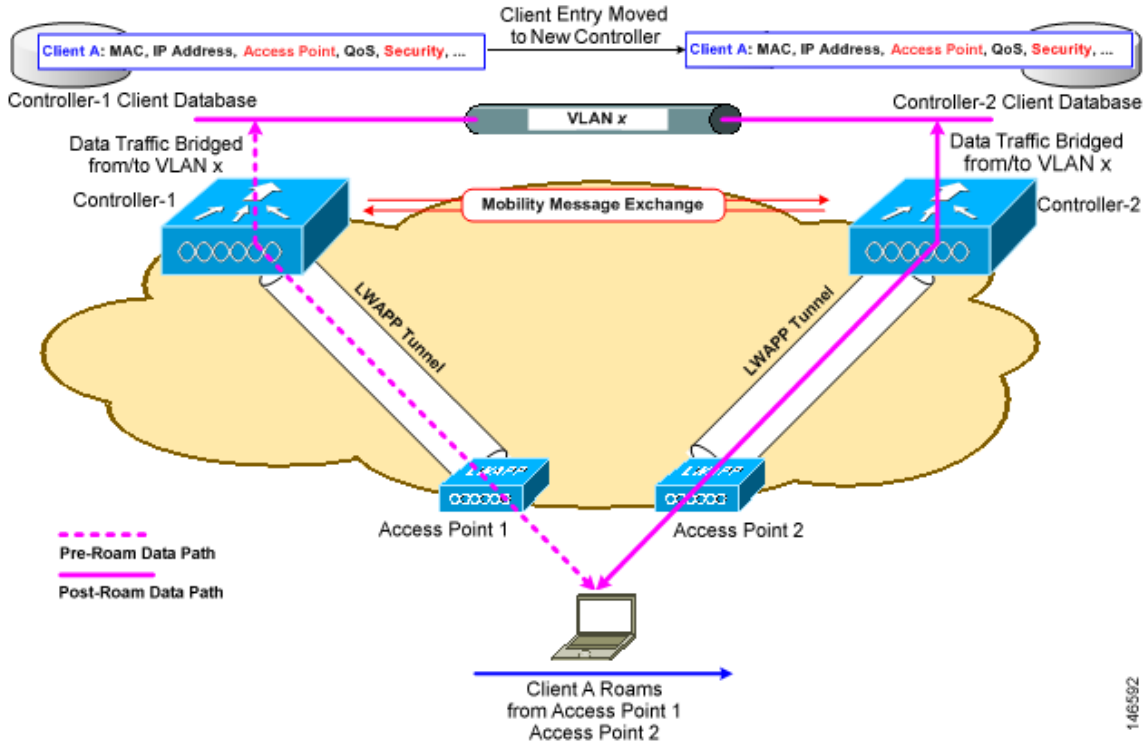
Figure 10-1 Intra-Controller Roaming



When the wireless client moves its association from one access point to another, the controller simply updates the client database with the newly associated access point. If necessary, new security context and associations are established as well.

The process becomes more complicated, however, when a client roams from an access point joined to one controller to an access point joined to a different controller. It also varies based on whether the controllers are operating on the same subnet. Figure 10-2 illustrates *inter-controller roaming*, which occurs when the controllers' wireless LAN interfaces are on the same IP subnet.

Figure 10-2 Inter-Controller Roaming

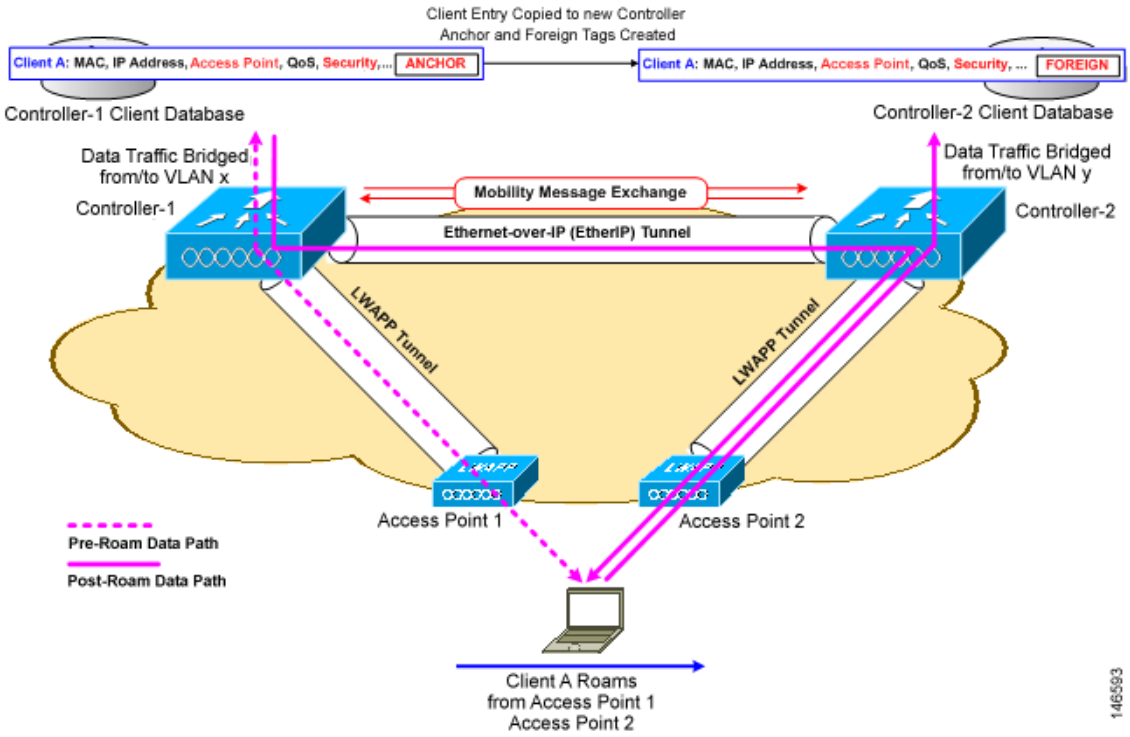


When the client associates to an access point joined to a new controller, the new controller exchanges mobility messages with the original controller, and the client database entry is moved to the new controller. New security context and associations are established if necessary, and the client database entry is updated for the new access point. This process remains transparent to the user.

Note All clients configured with 802.1x/Wi-Fi Protected Access (WPA) security complete a full authentication in order to comply with the IEEE standard.

Figure 10-3 illustrates *inter-subnet roaming*, which occurs when the controllers' wireless LAN interfaces are on different IP subnets.

Figure 10-3 Inter-Subnet Roaming



Inter-subnet roaming is similar to inter-controller roaming in that the controllers exchange mobility messages on the client roam. However, instead of moving the client database entry to the new controller, the original controller marks the client with an "Anchor" entry in its own client database. The database entry is copied to the new controller client database and marked with a "Foreign" entry in the new controller. The roam remains transparent to the wireless client, and the client maintains its original IP address.

After an inter-subnet roam, data to and from the wireless client flows in an asymmetric traffic path. Traffic from the client to the network is forwarded directly into the network by the foreign controller. Traffic to the client arrives at the anchor controller, which forwards the traffic to the foreign controller in an EtherIP tunnel. The foreign controller then forwards the data to the client. If a wireless client roams to a new foreign controller, the client database entry is moved from the original foreign controller to the new foreign controller, but the original anchor controller is always maintained. If the client moves back to the original controller, it becomes local again.

In inter-subnet roaming, WLANs on both anchor and foreign controllers need to have the same network access privileges and no source-based routing or source-based firewalls in place. Otherwise, the clients may have network connectivity issues after the handoff.

Note Currently, multicast traffic cannot be passed during inter-subnet roaming. With this in mind, you would not want to design an inter-subnet network for Spectralink phones that need to send multicast traffic while using push to talk.

Note Both inter-controller roaming and inter-subnet roaming require the controllers to be in the same mobility group. See the next two sections for a description of mobility groups and instructions for configuring them.

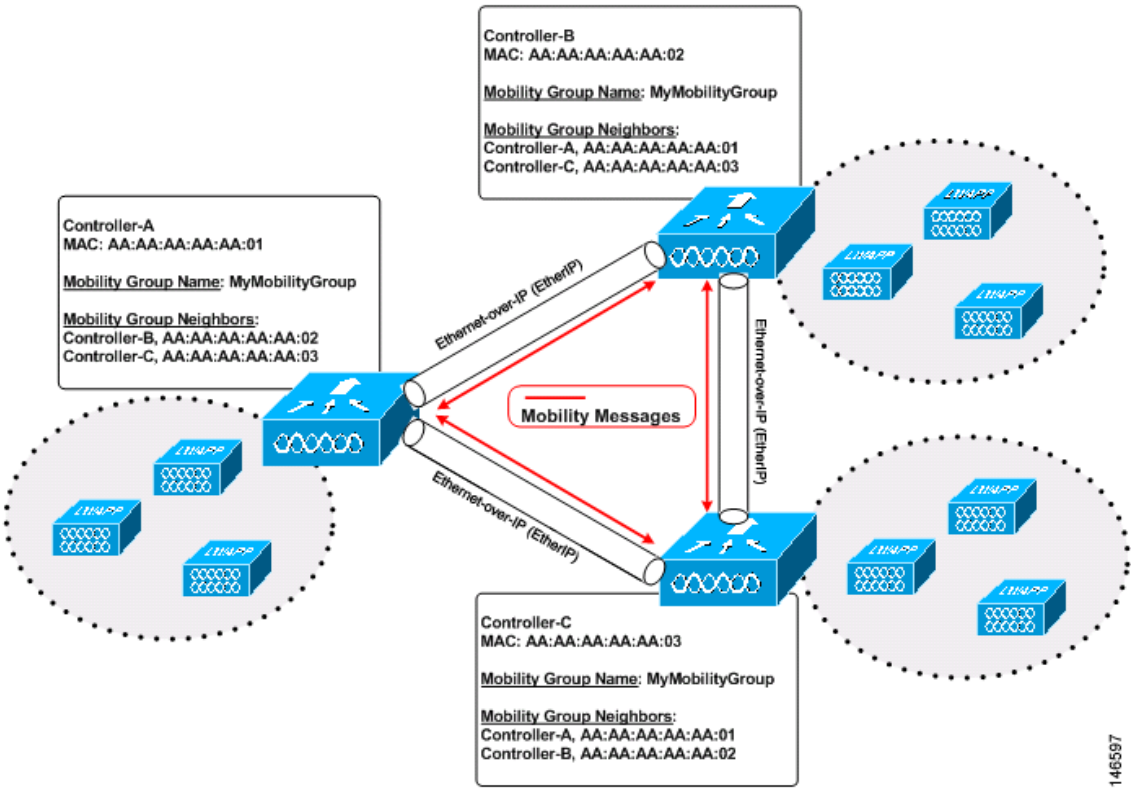
Overview of Mobility Groups

A set of controllers can be configured as a *mobility group* to allow seamless client roaming within a group of controllers. By creating a mobility group, you can enable multiple controllers in a network to dynamically share information and forward data traffic when inter-controller or inter-subnet roaming occurs. Controllers can share the context and state of client devices and controller loading information. With this information, the network can support inter-controller wireless LAN roaming and controller redundancy.

Note Clients do not roam across mobility groups.

Figure 10-4 shows an example of a mobility group.

Figure 10-4 A Single Mobility Group



As shown above, each controller is configured with a list of the other members of the mobility group. Whenever a new client joins a controller, the controller sends out a unicast message to all of the controllers in the mobility group. The controller to which the client was previously connected passes on the status of the client. All mobility exchange traffic between controllers is carried over an LWAPP tunnel. IPSec encryption can also be configured for the inter-controller mobility messages.

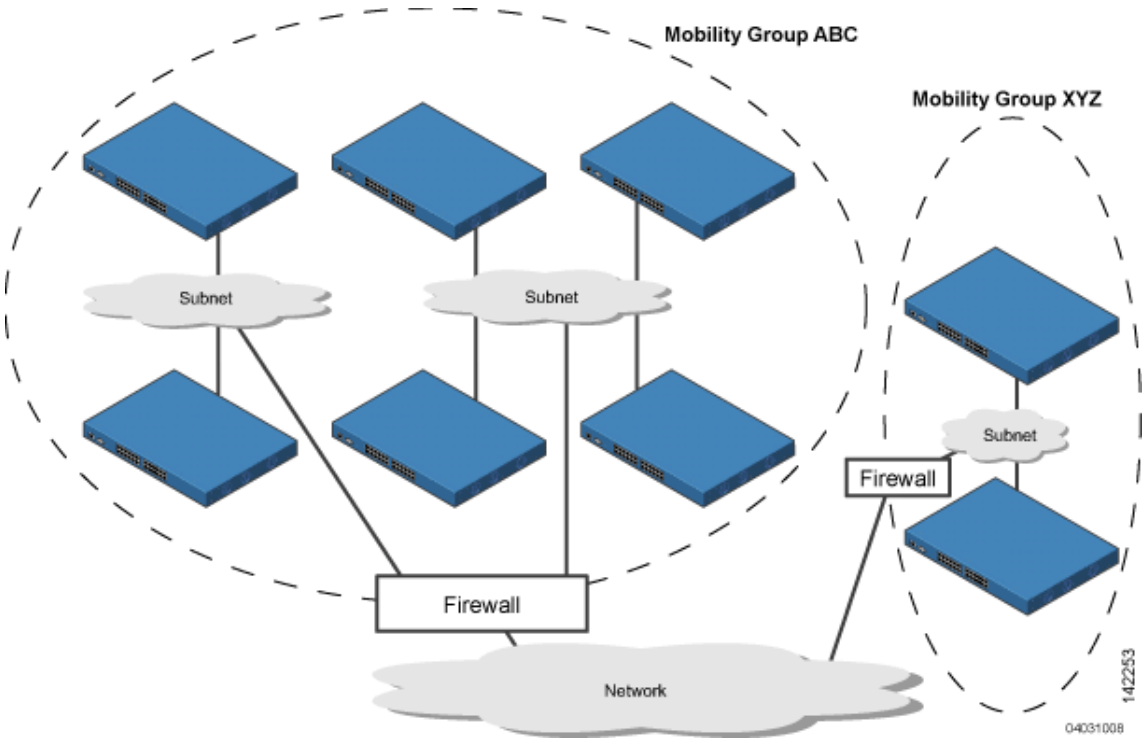
A mobility group can include up to 24 controllers of any type. The number of access points supported in a mobility group is bound by the number of controllers and controller types in the group.

Examples:

1. A 4404-100 controller supports up to 100 access points. Therefore, a mobility group consisting of 24 4404-100 controllers supports up to 2400 access points (24 * 100 = 2400 access points).
2. A 4402-25 controller supports up to 25 access points, and a 4402-50 controller supports up to 50 access points. Therefore, a mobility group consisting of 12 4402-25 controllers and 12 4402-50 controllers supports up to 900 access points (12 * 25 + 12 * 50 = 300 + 600 = 900 access points).

Mobility groups enable you to limit roaming between different floors, buildings, or campuses in the same enterprise by assigning different mobility group names to different controllers within the same wireless network. Figure 10-5 shows the results of creating distinct mobility group names for two groups of controllers.

Figure 10-5 Two Mobility Groups



The controllers in the ABC mobility group recognize and communicate with each other through their access points and through their shared subnets. The controllers in the ABC mobility group do not recognize or communicate with the XYZ controllers, which are in a different mobility group. Likewise, the controllers in the XYZ mobility group do not recognize or communicate with the controllers in the ABC mobility group. This feature ensures mobility group isolation across the network.

Note Clients may roam between access points in different mobility groups, provided they can hear them. However, their session information is not carried between controllers in different mobility groups.

Determining When to Include Controllers in a Mobility Group

If it is possible for a wireless client in your network to roam from an access point joined to one controller to an access point joined to another controller, both controllers should be in the same mobility group.

Configuring Mobility Groups

This section provides instructions for configuring controller mobility groups through either the GUI or the CLI.

Note You can also configure mobility groups using the Cisco Wireless Control System (WCS). Refer to the *Cisco Wireless Control System Configuration Guide* for instructions.

Prerequisites

Before you add controllers to a mobility group, you must verify that the following requirements have been met for all controllers that are to be included in the group:

- All controllers must be configured for the same LWAPP transport mode (Layer 2 or Layer 3).

  Note You can verify and, if necessary, change the LWAPP transport mode on the Controller > General page.

- IP connectivity must exist between the management interfaces of all controllers.

  Note You can verify IP connectivity by pinging the controllers.

- All controllers must be configured with the same mobility group name.

  Note The mobility group name is generally set at deployment time through the Startup Wizard. However, you can change it if necessary through the Default Mobility Domain Name field on the Controller > General page. The mobility group name is case sensitive.

  Note For the Cisco WiSM, both controllers should be configured with the same mobility group name for seamless routing among 300 access points.

- All controllers must be configured with the same virtual interface IP address.

Note If necessary, you can change the virtual interface IP address by editing the virtual interface name on the Controller > Interfaces page. See Chapter 3 for more information on the controller's virtual interface.

Note If all the controllers within a mobility group are not using the same virtual interface, inter-controller roaming may appear to work, but the hand-off does not complete, and the client loses connectivity for a period of time.

- You must have gathered the MAC address and IP address of every controller that is to be included in the mobility group. This information is necessary because you will be configuring all controllers with the MAC address and IP address of all the other mobility group members.

Note You can find the MAC and IP addresses of the other controllers to be included in the mobility group on the Controller > Mobility Groups page of each controller's GUI.

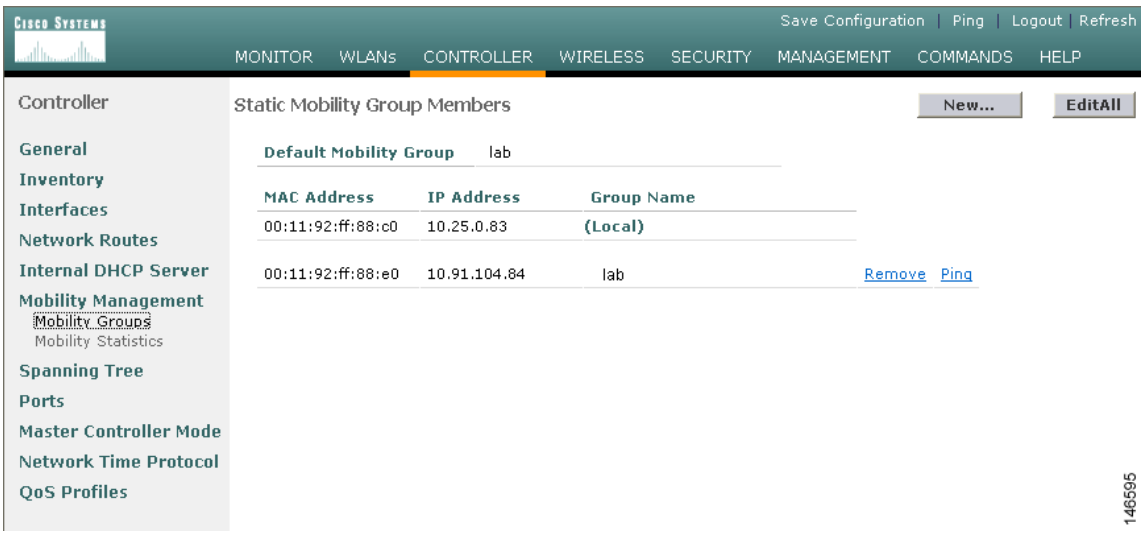
Using the GUI to Configure Mobility Groups

Follow these steps to configure mobility groups using the GUI.

Note See the "Using the CLI to Configure Mobility Groups" section on page 10-11 if you would prefer to configure mobility groups using the CLI.

Step 1 Click **Controller > Mobility Groups** to access the Static Mobility Group Members page (see Figure 10-6).

Figure 10-6 Static Mobility Group Members Page



This page shows the mobility group name in the Default Mobility Group field and lists the MAC address and IP address of each controller that is currently a member of the mobility group. The first entry is the local controller, which cannot be deleted.

Note Click **Remove** if you want to delete any of the remote controllers from the mobility group.

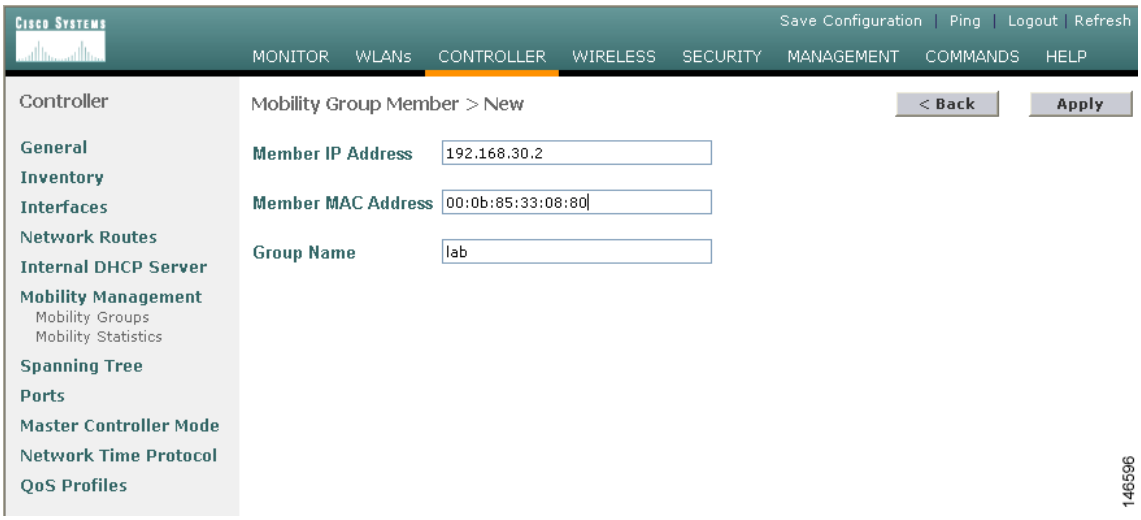
Step 2 Perform one of the following to add controllers to a mobility group:

- If you are adding only one controller or want to individually add multiple controllers, click **New** and go to Step 3.
- If you are adding multiple controllers and want to add them in bulk, click **EditAll** and go to Step 4.

Note The EditAll option enables you to enter the MAC and IP addresses of all the current mobility group members and then copy and paste all the entries from one controller to the other controllers in the mobility group.

Step 3 The Mobility Group Member > New page appears (see Figure 10-7).

Figure 10-7 Mobility Group Member > New Page



Follow these steps to add a controller to the mobility group:

a. In the Member IP Address field, enter the management interface IP address of the controller to be added.

b. In the Member MAC Address field, enter the MAC address of the controller to be added.

c. In the Group Name field, enter the name of the mobility group.

Note The mobility group name is case sensitive.

d. Click **Save Configuration** to save your changes. The new controller is added to the list of mobility group members on the Static Mobility Group Members page.

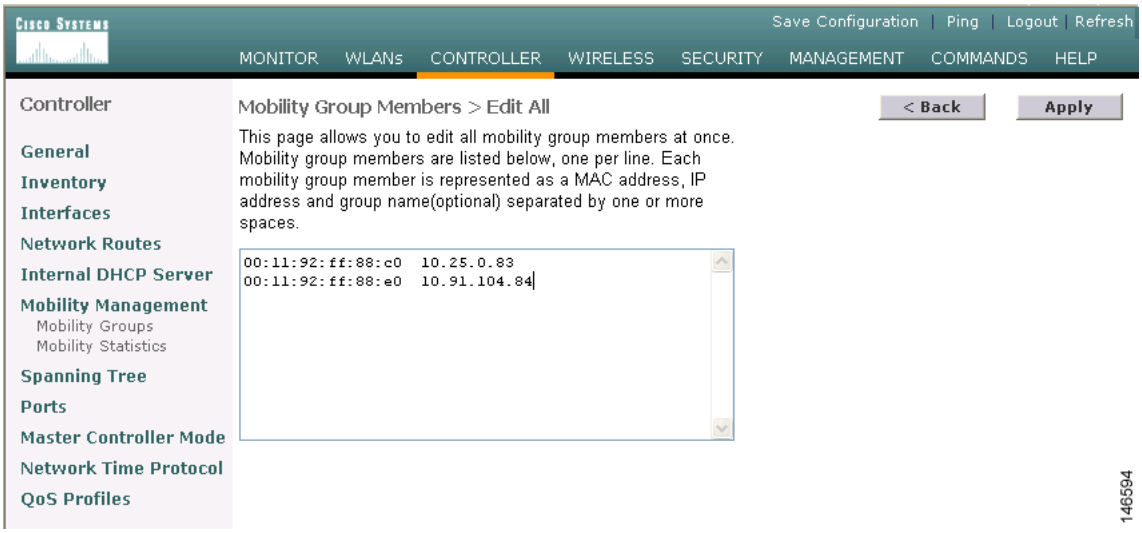
e. Repeat Step a through Step d to add all of the controllers in the mobility group.

f. Repeat this procedure on every controller to be included in the mobility group. All controllers in the mobility group must be configured with the MAC address and IP address of all other mobility group members.

Step 4 The Mobility Group Members > Edit All page (see Figure 10-8) lists the MAC address, IP address, and mobility group name (optional) of all the controllers currently in the mobility group. The controllers are listed one per line with the local controller at the top of the list.

Note If desired, you can edit or delete any of the controllers in the list.

Figure 10-8 Mobility Group Members > Edit All Page



Follow these steps to add more controllers to the mobility group:

a. Click inside the edit box to start a new line.

b. Enter the MAC address, the management interface IP address, and the name of the mobility group for the controller to be added.

Note These values should be entered on one line and separated by one or two spaces.

Note The mobility group name is case sensitive.

c. Repeat Step a and Step b for each additional controller that you want to add to the mobility group.

d. Highlight and copy the complete list of entries in the edit box.

e. Click **Save Configuration** to save your changes. The new controllers are added to the list of mobility group members on the Static Mobility Group Members page.

f. Paste the list into the edit box on the Mobility Group Members > Edit All page of all the other controllers in the mobility group and click **Save Configuration**.

Using the CLI to Configure Mobility Groups

Follow these steps to configure mobility groups using the CLI.

Step 1 Enter **show mobility summary** to check the current mobility settings.

Step 2 Enter **config mobility group name** *group_name* to create a mobility group.

Note Enter up to 31 case-sensitive ASCII characters for the group name. Spaces are not allowed in mobility group names.

Step 3 Enter **config mobility group member add** *mac-address ip-addr* to add a group member.

Note Enter **config mobility group member delete** *mac-address ip-addr* if you want to delete a group member.

Step 4 Enter **show mobility summary** to verify the mobility configuration.

Step 5 Repeat this procedure on every controller to be included in the mobility group. All controllers in the mobility group must be configured with the MAC address and IP address of all other mobility group members.

Configuring Auto-Anchor Mobility

Use auto-anchor mobility (or *guest WLAN mobility)* to improve load balancing and security for roaming clients on your wireless LANs. Under normal roaming conditions, client devices join a wireless LAN and are anchored to the first controller that they contact. If a client roams to a different subnet, the controller to which the client roamed sets up a foreign session for the client with the anchor controller. However, using the auto-anchor mobility feature, you can specify a controller or set of controllers as the anchor points for clients on a wireless LAN.

In auto-anchor mobility mode, a subset of a mobility group is specified as the anchor controllers for a WLAN. You can use this feature to restrict a WLAN to a single subnet, regardless of a client's entry point into the network. Clients can then access a guest WLAN throughout an enterprise but still be restricted to a specific subnet. Auto-anchor mobility can also provide geographic load balancing because the WLANs can represent a particular section of a building (such as a lobby, a restaurant, and so on), effectively creating a set of home controllers for a WLAN. Instead of being anchored to the first controller that they happen to contact, mobile clients can be anchored to controllers that control access points in a particular vicinity.

When a client first associates to a controller of a mobility group that has been preconfigured as a mobility anchor for a WLAN, the client associates to the controller locally, and a local session is created for the client. Clients can be anchored only to preconfigured anchor controllers of the WLAN. For a given WLAN, you should configure the same set of anchor controllers on all controllers in the mobility group.

When a client first associates to a controller of a mobility group that has not been configured as a mobility anchor for a WLAN, the client associates to the controller locally, a local session is created for the client, and the controller is announced to the other controllers in the same mobility group. If the announcement is not answered, the controller contacts one of the anchor controllers configured for the

WLAN and creates a foreign session for the client on the local switch. Packets from the client are encapsulated through a mobility tunnel using EtherIP and sent to the anchor controller, where they are decapsulated and delivered to the wired network. Packets to the client are received by the anchor controller and forwarded to the foreign controller through a mobility tunnel using EtherIP. The foreign controller decapsulates the packets and forwards them to the client.

Note A 2000 series controller cannot be designated as an anchor for a WLAN. However, a WLAN created on a 2000 series controller can have a 4100 series controller or a 4400 series controller as its anchor.

Note The IPSec and L2TP Layer 3 security policies are unavailable for WLANs configured with a mobility anchor.

Guidelines for Using Auto-Anchor Mobility

Keep these guidelines in mind when you configure auto-anchor mobility:

- Controllers must be added to the mobility group member list before you can designate them as mobility anchors for a WLAN.
- You can configure multiple controllers as mobility anchors for a WLAN.
- You must disable the WLAN before configuring mobility anchors for it.
- Auto-anchor mobility supports web authorization but does not support other Layer 3 security types.
- The WLANs on both the foreign controller and the anchor controller must be configured with mobility anchors. On the anchor controller, configure the anchor controller itself as a mobility anchor. On the foreign controller, configure the anchor as a mobility anchor.

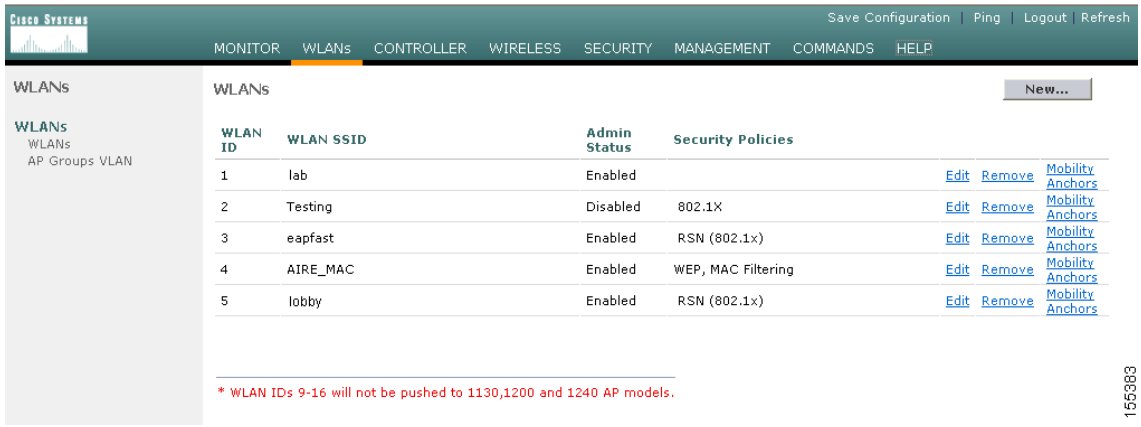
Using the GUI to Configure Auto-Anchor Mobility

Follow these steps to create a new mobility anchor for a WLAN using the GUI.

Note See the "Using the CLI to Configure Auto-Anchor Mobility" section on page 10-14 if you would prefer to configure auto-anchor mobility using the CLI.

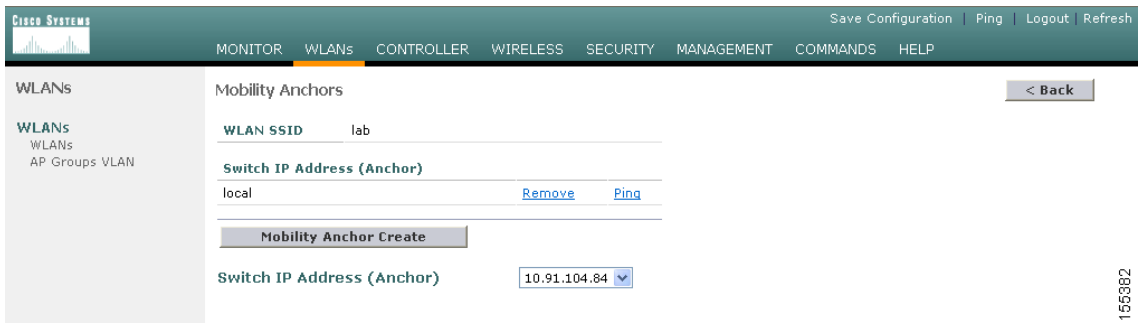
Step 1 Click **Controller > WLANs** to access the WLANs page (see Figure 10-9).

Figure 10-9 WLANs Page



Step 2 On the WLANs page, click the **Mobility Anchors** link for the desired WLAN. The Mobility Anchors page for that WLAN appears (see Figure 10-10).

Figure 10-10 Mobility Anchors Page



Step 3 Select the IP address of the controller to be designated a mobility anchor in the Switch IP Address (Anchor) drop-down box.

Step 4 Click **Mobility Anchor Create**. The selected controller becomes an anchor for this WLAN.

Note To delete a mobility anchor for a WLAN, click **Remove** to the right of the controller's IP address.

Step 5 Repeat Step 3 and Step 4 to set any other controllers as mobility anchors for this WLAN.

Step 6 Configure the same set of anchor controllers on every controller in the mobility group.

Using the CLI to Configure Auto-Anchor Mobility

Use these commands to configure auto-anchor mobility using the CLI.

1. Enter **config wlan disable** *wlan-id* to disable the WLAN for which you are configuring anchor controllers.
2. To create a new mobility anchor for the WLAN, enter one of these commands:
   - **config mobility group anchor add** *wlan-id anchor-controller-ip-address*
   - **config wlan mobility anchor add** *wlan-id anchor-controller-ip-address*

   Note The *wlan-id* must exist and be disabled, and the *anchor-controller-ip-address* must be a member of the default mobility group.

   Note Auto-anchor mobility is enabled for the WLAN when you configure the first anchor controller.
3. To delete a mobility anchor for the WLAN, enter one of these commands:
   - **config mobility group anchor delete** *wlan-id anchor-controller-ip-address*
   - **config wlan mobility anchor delete** *wlan-id anchor-controller-ip-address*

   Note The *wlan-id* must exist and be disabled.

   Note Deleting the last anchor disables the auto-anchor mobility feature and resumes normal mobility for new associations.
4. To see the list of controllers configured as mobility anchors for a specific WLAN, enter one of these commands:
   - **show mobility anchor** [*wlan-id*]
   - **show wlan mobility anchor** [*wlan-id*]

   Note The *wlan-id* is optional and constrains the list to the anchors in a particular WLAN. To see all of the mobility anchors on your system, enter **show mobility anchor**.

Safety Considerations and Translated Safety Warnings

This appendix lists safety considerations and translations of the safety warnings that apply to the Cisco Unified Wireless Network Solution products. The following safety considerations and safety warnings appear in this appendix:

Safety Considerations

Keep these guidelines in mind when installing Cisco Wireless LAN Solution products:

- The Cisco 1000 Series lightweight access points with or without external antenna ports are only intended for installation in Environment A as defined in IEEE 802.3af. All interconnected equipment must be contained within the same building including the interconnected equipment's associated LAN connections.
- For AP1020 and AP1030 Cisco 1000 Series lightweight access points provided with optional external antenna ports, make sure that all external antennas and their associated wiring are located entirely indoors. Cisco 1000 Series lightweight access points and their optional external antennas are not suitable for outdoor use.
- Make sure that plenum-mounted Cisco 1000 Series lightweight access points are powered using Power over Ethernet (PoE) to comply with safety regulations.
- For all Cisco Wireless LAN Controllers, verify that the ambient temperature remains between 0 and 40° C (32 and 104° F), taking into account the elevated temperatures that occur when they are installed in a rack.
- When multiple Cisco Wireless LAN Controllers are mounted in an equipment rack, be sure that the power source is sufficiently rated to safely run all of the equipment in the rack.
- Verify the integrity of the ground before installing Cisco Wireless LAN Controllers in an equipment rack.
- Lightweight access points are suitable for use in environmental air space in accordance with Section 300.22.C of the National Electrical Code, and Sections 2-128, 12-010(3) and 12-100 of the Canadian Electrical Code, Part 1, C22.1.

Warning Definition

Warning **IMPORTANT SAFETY INSTRUCTIONS**

This warning symbol means danger. You are in a situation that could cause bodily injury. Before you work on any equipment, be aware of the hazards involved with electrical circuitry and be familiar with standard practices for preventing accidents. Use the statement number provided at the end of each warning to locate its translation in the translated safety warnings that accompanied this device. Statement 1071

SAVE THESE INSTRUCTIONS

Waarschuwing **BELANGRIJKE VEILIGHEIDSINSTRUCTIES**

Dit waarschuwingssymbool betekent gevaar. U verkeert in een situatie die lichamelijk letsel kan veroorzaken. Voordat u aan enige apparatuur gaat werken, dient u zich bewust te zijn van de bij elektrische schakelingen betrokken risico's en dient u op de hoogte te zijn van de standaard praktijken om ongelukken te voorkomen. Gebruik het nummer van de verklaring onderaan de waarschuwing als u een vertaling van de waarschuwing die bij het apparaat wordt geleverd, wilt raadplegen.

BEWAAR DEZE INSTRUCTIES

Varoitus **TÄRKEITÄ TURVALLISUUSOHJEITA**

Tämä varoitusmerkki merkitsee vaaraa. Tilanne voi aiheuttaa ruumiillisia vammoja. Ennen kuin käsittelet laitteistoa, huomioi sähköpiirien käsittelemiseen liittyvät riskit ja tutustu onnettomuuksien yleisiin ehkäisytapoihin. Turvallisuusvaroitusten käännökset löytyvät laitteen mukana toimitettujen käännettyjen turvallisuusvaroitusten joukosta varoitusten lopussa näkyvien lausuntonumeroiden avulla.

SÄILYTÄ NÄMÄ OHJEET

Attention **IMPORTANTES INFORMATIONS DE SÉCURITÉ**

Ce symbole d'avertissement indique un danger. Vous vous trouvez dans une situation pouvant entraîner des blessures ou des dommages corporels. Avant de travailler sur un équipement, soyez conscient des dangers liés aux circuits électriques et familiarisez-vous avec les procédures couramment utilisées pour éviter les accidents. Pour prendre connaissance des traductions des avertissements figurant dans les consignes de sécurité traduites qui accompagnent cet appareil, référez-vous au numéro de l'instruction situé à la fin de chaque avertissement.

CONSERVEZ CES INFORMATIONS

Warnung **WICHTIGE SICHERHEITSHINWEISE**

Dieses Warnsymbol bedeutet Gefahr. Sie befinden sich in einer Situation, die zu Verletzungen führen kann. Machen Sie sich vor der Arbeit mit Geräten mit den Gefahren elektrischer Schaltungen und den üblichen Verfahren zur Vorbeugung vor Unfällen vertraut. Suchen Sie mit der am Ende jeder Warnung angegebenen Anweisungsnummer nach der jeweiligen Übersetzung in den übersetzten Sicherheitshinweisen, die zusammen mit diesem Gerät ausgeliefert wurden.

BEWAHREN SIE DIESE HINWEISE GUT AUF.

Avvertenza **IMPORTANTI ISTRUZIONI SULLA SICUREZZA**

Questo simbolo di avvertenza indica un pericolo. La situazione potrebbe causare infortuni alle persone. Prima di intervenire su qualsiasi apparecchiatura, occorre essere al corrente dei pericoli relativi ai circuiti elettrici e conoscere le procedure standard per la prevenzione di incidenti. Utilizzare il numero di istruzione presente alla fine di ciascuna avvertenza per individuare le traduzioni delle avvertenze riportate in questo documento.

CONSERVARE QUESTE ISTRUZIONI

Advarsel **VIKTIGE SIKKERHETSINSTRUKSJONER**

Dette advarselssymbolet betyr fare. Du er i en situasjon som kan føre til skade på person. Før du begynner å arbeide med noe av utstyret, må du være oppmerksom på farene forbundet med elektriske kretser, og kjenne til standardprosedyrer for å forhindre ulykker. Bruk nummeret i slutten av hver advarsel for å finne oversettelsen i de oversatte sikkerhetsadvarslene som fulgte med denne enheten.

TA VARE PÅ DISSE INSTRUKSJONENE

Aviso **INSTRUÇÕES IMPORTANTES DE SEGURANÇA**

Este símbolo de aviso significa perigo. Você está em uma situação que poderá ser causadora de lesões corporais. Antes de iniciar a utilização de qualquer equipamento, tenha conhecimento dos perigos envolvidos no manuseio de circuitos elétricos e familiarize-se com as práticas habituais de prevenção de acidentes. Utilize o número da instrução fornecido ao final de cada aviso para localizar sua tradução nos avisos de segurança traduzidos que acompanham este dispositivo.

GUARDE ESTAS INSTRUÇÕES

¡Advertencia! **INSTRUCCIONES IMPORTANTES DE SEGURIDAD**

Este símbolo de aviso indica peligro. Existe riesgo para su integridad física. Antes de manipular cualquier equipo, considere los riesgos de la corriente eléctrica y familiarícese con los procedimientos estándar de prevención de accidentes. Al final de cada advertencia encontrará el número que le ayudará a encontrar el texto traducido en el apartado de traducciones que acompaña a este dispositivo.

GUARDE ESTAS INSTRUCCIONES

Varning! **VIKTIGA SÄKERHETSANVISNINGAR**

Denna varningssignal signalerar fara. Du befinner dig i en situation som kan leda till personskada. Innan du utför arbete på någon utrustning måste du vara medveten om farorna med elkretsar och känna till vanliga förfaranden för att förebygga olyckor. Använd det nummer som finns i slutet av varje varning för att hitta dess översättning i de översatta säkerhetsvarningar som medföljer denna anordning.

SPARA DESSA ANVISNINGAR

Figyelem **FONTOS BIZTONSÁGI ELOÍRÁSOK**

Ez a figyelmezeto jel veszélyre utal. Sérülésveszélyt rejto helyzetben van. Mielott bármely berendezésen munkát végezte, legyen figyelemmel az elektromos áramkörök okozta kockázatokra, és ismerkedjen meg a szokásos balesetvédelmi eljárásokkal. A kiadványban szereplo figyelmeztetések fordítása a készülékhez mellékelt biztonsági figyelmeztetések között található; a fordítás az egyes figyelmeztetések végén látható szám alapján keresheto meg.

ORIZZE MEG EZEKET AZ UTASÍTÁSOKAT!

Предупреждение **ВАЖНЫЕ ИНСТРУКЦИИ ПО СОБЛЮДЕНИЮ ТЕХНИКИ БЕЗОПАСНОСТИ**

Этот символ предупреждения обозначает опасность. То есть имеет место ситуация, в которой следует опасаться телесных повреждений. Перед эксплуатацией оборудования выясните, каким опасностям может подвергаться пользователь при использовании электрических цепей, и ознакомьтесь с правилами техники безопасности для предотвращения возможных несчастных случаев. Воспользуйтесь номером заявления, приведенным в конце каждого предупреждения, чтобы найти его переведенный вариант в переводе предупреждений по безопасности, прилагаемом к данному устройству.

СОХРАНИТЕ ЭТИ ИНСТРУКЦИИ

警告 重要的安全性说明

此警告符号代表危险。您正处于可能受到严重伤害的工作环境中。在您使用设备开始工作之前，必须充分意识到触电的危险，并熟练掌握防止事故发生的标准工作程序。请根据每项警告结尾提供的声明号码来找到此设备的安全性警告说明的翻译文本。

请保存这些安全性说明

警告 安全上の重要な注意事項

「危険」の意味です。人身事故を予防するための注意事項が記述されています。装置の取り扱い作業を行うときは、電気回路の危険性に注意し、一般的な事故防止策に留意してください。警告の各国語版は、各注意事項の番号を基に、装置に付属の「Translated Safety Warnings」を参照してください。

これらの注意事項を保管しておいてください。

Class 1 Laser Product Warning

Note The 1000BASE-SX and 1000BASE-LX SFP modules and AIR-WLC4112-K9, AIR-WLC4124-K9, and AIR-WLC4136-K9 Cisco 4100 Series Wireless LAN Controllers contain Class 1 Lasers (Laser Klasse 1) according to EN 60825-1+A1+A2.

Warning **Class 1 laser product.** Statement 1008

Waarschuwing **Klasse-1 laser produkt.**

Varoitus **Luokan 1 lasertuote.**

Attention **Produit laser de classe 1.**

Warnung **Laserprodukt der Klasse 1.**

Avvertenza **Prodotto laser di Classe 1.**

Advarsel **Laserprodukt av klasse 1.**

Aviso **Produto laser de classe 1.**

¡Advertencia! **Producto láser Clase I.**

Varning! **Laserprodukt av klass 1.**

Figyelem	**Class 1 besorolású lézeres termék.**
Предупреждение	Лазерное устройство класса 1.
警告	这是 1 类激光产品。
警告	クラス1レーザー製品です。
주의	클래스 1 레이저 제품.
Aviso	**Produto a laser de classe 1.**
Advarsel	**Klasse 1 laserprodukt.**
تحذير	**Class 1 Laser منتج ١**
Upozorenje	**Laserski proizvod klase 1**
Upozornění	**Laserový výrobek třídy 1.**
Προειδοποίηση	Προϊόν λέιζερ κατηγορίας 1.
אזהרה	.Class 1 מוצר לייזר
Opomena	Ласерски производ од класа 1.
Ostrzeżenie	**Produkt laserowy klasy 1.**
Upozornenie	**Laserový výrobok triedy 1.**

Figyelem	**Class 1 besorolású lézeres termék.**
Предупреждение	Лазерное устройство класса 1.
警告	这是 1 类激光产品。
警告	クラス1レーザー製品です。

주의 클래스 1 레이저 제품.

تحذير **Class 1 Laser منتج ١**

Upozorenje **Laserski proizvod klase 1**

Upozornění **Laserový výrobek třídy 1.**

Προειδοποίηση Προϊόν λέιζερ κατηγορίας 1.

אזהרה .Class 1 מוצר לייזר

Opomena Ласерски производ од класа 1.

Ostrzeżenie **Produkt laserowy klasy 1.**

Upozornenie **Laserový výrobok triedy 1.**

Ground Conductor Warning

Warning **This equipment must be grounded. Never defeat the ground conductor or operate the equipment in the absence of a suitably installed ground conductor. Contact the appropriate electrical inspection authority or an electrician if you are uncertain that suitable grounding is available.** Statement 1024

Waarschuwing **Deze apparatuur dient geaard te zijn. De aardingsleiding mag nooit buiten werking worden gesteld en de apparatuur mag nooit bediend worden zonder dat er een op de juiste wijze geïnstalleerde aardingsleiding aanwezig is. Neem contact op met de bevoegde instantie voor elektrische inspecties of met een elektricien als u er niet zeker van bent dat er voor passende aarding gezorgd is.**

Varoitus **Laitteiden on oltava maadoitettuja. Älä koskaan ohita maajohdinta tai käytä laitteita ilman oikein asennettua maajohdinta. Ota yhteys sähkötarkastusviranomaiseen tai sähköasentajaan, jos olet epävarma maadoituksen sopivuudesta.**

Attention **Cet équipement doit être mis à la masse. Ne jamais rendre inopérant le conducteur de masse ni utiliser l'équipement sans un conducteur de masse adéquatement installé. En cas de doute sur la mise à la masse appropriée disponible, s'adresser à l'organisme responsable de la sécurité électrique ou à un électricien.**

Warnung **Dieses Gerät muss geerdet sein. Auf keinen Fall den Erdungsleiter unwirksam machen oder das Gerät ohne einen sachgerecht installierten Erdungsleiter verwenden. Wenn Sie sich nicht sicher sind, ob eine sachgerechte Erdung vorhanden ist, wenden Sie sich an die zuständige Inspektionsbehörde oder einen Elektriker.**

Avvertenza **Questa apparecchiatura deve essere dotata di messa a terra. Non escludere mai il conduttore di protezione né usare l'apparecchiatura in assenza di un conduttore di protezione installato in modo corretto. Se non si è certi della disponibilità di un adeguato collegamento di messa a terra, richiedere un controllo elettrico presso le autorità competenti o rivolgersi a un elettricista.**

Advarsel **Dette utstyret må jordes. Omgå aldri jordingslederen og bruk aldri utstyret uten riktig montert jordingsleder. Ta kontakt med fagfolk innen elektrisk inspeksjon eller med en elektriker hvis du er usikker på om det finnes velegnet jordning.**

Aviso **Este equipamento deve ser aterrado. Nunca anule o fio terra nem opere o equipamento sem um aterramento adequadamente instalado. Em caso de dúvida com relação ao sistema de aterramento disponível, entre em contato com os serviços locais de inspeção elétrica ou um eletricista qualificado.**

¡Advertencia! **Este equipo debe estar conectado a tierra. No inhabilite el conductor de tierra ni haga funcionar el equipo si no hay un conductor de tierra instalado correctamente. Póngase en contacto con la autoridad correspondiente de inspección eléctrica o con un electricista si no está seguro de que haya una conexión a tierra adecuada.**

Varning! **Denna utrustning måste jordas. Koppla aldrig från jordledningen och använd aldrig utrustningen utan en på lämpligt sätt installerad jordledning. Om det föreligger osäkerhet huruvida lämplig jordning finns skall elektrisk besiktningsauktoritet eller elektriker kontaktas.**

Figyelem **A berendezés csak megfelelő védőföldeléssel működtethető. Ne iktassa ki a földelés csatlakozóját, és ne üzemeltesse a berendezést szabályosan felszerelt földelő vezeték nélkül! Ha nem biztos benne, hogy megfelelő földelés áll rendelkezésbe, forduljon a helyi elektromos hatóságokhoz vagy egy villanyszerelőhöz.**

Предупреждение Данное устройство должно быть заземлено. Никогда не отключайте провод заземления и не пользуйтесь оборудованием при отсутствии правильно подключенного провода заземления. За сведениями об имеющихся возможностях заземления обратитесь к соответствующим контролирующим организациям по энергоснабжению или к инженеру-электрику.

警告 此设备必须接地。切勿使接地导体失效，或者在没有正确安装接地导体的情况下操作该设备。如果您不能肯定接地导体是否正常发挥作用，请咨询有关电路检测方面的权威人士或电工。

警告 この装置はアース接続する必要があります。アース導体を破損しないよう注意し、アース導体を正しく取り付けないまま装置を稼働させないでください。アース接続が適正であるかどうか分からない場合には、電気検査機関または電気技術者に相談してください。

Figyelem **A berendezés csak megfelelő védőföldeléssel működtethető. Ne iktassa ki a földelés csatlakozóját, és ne üzemeltesse a berendezést szabályosan felszerelt földelő vezeték nélkül! Ha nem biztos benne, hogy megfelelő földelés áll rendelkezésbe, forduljon a helyi elektromos hatóságokhoz vagy egy villanyszerelőhöz.**

Предупреждение Данное устройство должно быть заземлено. Никогда не отключайте провод заземления и не пользуйтесь оборудованием при отсутствии правильно подключенного провода заземления. За сведениями об имеющихся возможностях заземления обратитесь к соответствующим контролирующим организациям по энергоснабжению или к инженеру-электрику.

警告 此设备必须接地。切勿使接地导体失效，或者在没有正确安装接地导体的情况下操作该设备。如果您不能肯定接地导体是否正常发挥作用，请咨询有关电路检测方面的权威人士或电工。

警告 この装置はアース接続する必要があります。アース導体を破損しないよう注意し、アース導体を正しく取り付けないまま装置を稼働させないでください。アース接続が適正であるかどうか分からない場合には、電気検査機関または電気技術者に相談してください。

Chassis Warning for Rack-Mounting and Servicing

Warning **To prevent bodily injury when mounting or servicing this unit in a rack, you must take special precautions to ensure that the system remains stable. The following guidelines are provided to ensure your safety:**

- **This unit should be mounted at the bottom of the rack if it is the only unit in the rack.**
- **When mounting this unit in a partially filled rack, load the rack from the bottom to the top with the heaviest component at the bottom of the rack.**
- **If the rack is provided with stabilizing devices, install the stabilizers before mounting or servicing the unit in the rack.** Statement 1006

Waarschuwing **Om lichamelijk letsel te voorkomen wanneer u dit toestel in een rek monteert of het daar een servicebeurt geeft, moet u speciale voorzorgsmaatregelen nemen om ervoor te zorgen dat het toestel stabiel blijft. De onderstaande richtlijnen worden verstrekt om uw veiligheid te verzekeren:**

- **Dit toestel dient onderaan in het rek gemonteerd te worden als het toestel het enige in het rek is.**
- **Wanneer u dit toestel in een gedeeltelijk gevuld rek monteert, dient u het rek van onderen naar boven te laden met het zwaarste onderdeel onderaan in het rek.**
- **Als het rek voorzien is van stabiliseringshulpmiddelen, dient u de stabilisatoren te monteren voordat u het toestel in het rek monteert of het daar een servicebeurt geeft.**

Varoitus **Kun laite asetetaan telineeseen tai huolletaan sen ollessa telineessä, on noudatettava erityisiä varotoimia järjestelmän vakavuuden säilyttämiseksi, jotta vältytään loukkaantumiselta. Noudata seuraavia turvallisuusohjeita:**

- **Jos telineessä ei ole muita laitteita, aseta laite telineen alaosaan.**
- **Jos laite asetetaan osaksi täytettyyn telineeseen, aloita kuormittaminen sen alaosasta kaikkein raskaimmalla esineellä ja siirry sitten sen yläosaan.**
- **Jos telinettä varten on vakaimet, asenna ne ennen laitteen asettamista telineeseen tai sen huoltamista siinä.**

Attention **Pour éviter toute blessure corporelle pendant les opérations de montage ou de réparation de cette unité en casier, il convient de prendre des précautions spéciales afin de maintenir la stabilité du système. Les directives ci-dessous sont destinées à assurer la protection du personnelþ:**

- **Si cette unité constitue la seule unité montée en casier, elle doit être placée dans le bas.**
- **Si cette unité est montée dans un casier partiellement rempli, charger le casier de bas en haut en plaçant l'élément le plus lourd dans le bas.**
- **Si le casier est équipé de dispositifs stabilisateurs, installer les stabilisateurs avant de monter ou de réparer l'unité en casier.**

Warnung **Zur Vermeidung von Körperverletzung beim Anbringen oder Warten dieser Einheit in einem Gestell müssen Sie besondere Vorkehrungen treffen, um sicherzustellen, daß das System stabil bleibt. Die folgenden Richtlinien sollen zur Gewährleistung Ihrer Sicherheit dienen:**

- **Wenn diese Einheit die einzige im Gestell ist, sollte sie unten im Gestell angebracht werden.**
- **Bei Anbringung dieser Einheit in einem zum Teil gefüllten Gestell ist das Gestell von unten nach oben zu laden, wobei das schwerste Bauteil unten im Gestell anzubringen ist.**
- **Wird das Gestell mit Stabilisierungszubehör geliefert, sind zuerst die Stabilisatoren zu installieren, bevor Sie die Einheit im Gestell anbringen oder sie warten.**

Avvertenza **Per evitare infortuni fisici durante il montaggio o la manutenzione di questa unità in un supporto, occorre osservare speciali precauzioni per garantire che il sistema rimanga stabile. Le seguenti direttive vengono fornite per garantire la sicurezza personale:**

- **Questa unità deve venire montata sul fondo del supporto, se si tratta dell'unica unità da montare nel supporto.**
- **Quando questa unità viene montata in un supporto parzialmente pieno, caricare il supporto dal basso all'alto, con il componente più pesante sistemato sul fondo del supporto.**
- **Se il supporto è dotato di dispositivi stabilizzanti, installare tali dispositivi prima di montare o di procedere alla manutenzione dell'unità nel supporto.**

Advarsel **Unngå fysiske skader under montering eller reparasjonsarbeid på denne enheten når den befinner seg i et kabinett. Vær nøye med at systemet er stabilt. Følgende retningslinjer er gitt for å verne om sikkerheten:**

- **Denne enheten bør monteres nederst i kabinettet hvis dette er den eneste enheten i kabinettet.**
- **Ved montering av denne enheten i et kabinett som er delvis fylt, skal kabinettet lastes fra bunnen og opp med den tyngste komponenten nederst i kabinettet.**
- **Hvis kabinettet er utstyrt med stabiliseringsutstyr, skal stabilisatorene installeres før montering eller utføring av reparasjonsarbeid på enheten i kabinettet.**

Aviso **Para se prevenir contra danos corporais ao montar ou reparar esta unidade numa estante, deverá tomar precauções especiais para se certificar de que o sistema possui um suporte estável. As seguintes directrizes ajudá-lo-ão a efectuar o seu trabalho com segurança:**

- **Esta unidade deverá ser montada na parte inferior da estante, caso seja esta a única unidade a ser montada.**
- **Ao montar esta unidade numa estante parcialmente ocupada, coloque os itens mais pesados na parte inferior da estante, arrumando-os de baixo para cima.**
- **Se a estante possuir um dispositivo de estabilização, instale-o antes de montar ou reparar a unidade.**

¡Advertencia! **Para evitar lesiones durante el montaje de este equipo sobre un bastidor, o posteriormente durante su mantenimiento, se debe poner mucho cuidado en que el sistema quede bien estable. Para garantizar su seguridad, proceda según las siguientes instrucciones:**

- **Colocar el equipo en la parte inferior del bastidor, cuando sea la única unidad en el mismo.**
- **Cuando este equipo se vaya a instalar en un bastidor parcialmente ocupado, comenzar la instalación desde la parte inferior hacia la superior colocando el equipo más pesado en la parte inferior.**
- **Si el bastidor dispone de dispositivos estabilizadores, instalar éstos antes de montar o proceder al mantenimiento del equipo instalado en el bastidor.**

Varning! **För att undvika kroppsskada när du installerar eller utför underhållsarbete på denna enhet på en ställning måste du vidta särskilda försiktighetsåtgärder för att försäkra dig om att systemet står stadigt. Följande riktlinjer ges för att trygga din säkerhet:**

- **Om denna enhet är den enda enheten på ställningen skall den installeras längst ned på ställningen.**
- **Om denna enhet installeras på en delvis fylld ställning skall ställningen fyllas nedifrån och upp, med de tyngsta enheterna längst ned på ställningen.**
- **Om ställningen är försedd med stabiliseringsdon skall dessa monteras fast innan enheten installeras eller underhålls på ställningen.**

Figyelem **A készülék rackbe történő beszerelése és karbantartása során bekövetkező sérülések elkerülése végett speciális óvintézkedésekkel meg kell őrizni a rendszer stabilitását. A személyes biztonsága érdekében tartsa be a következő szabályokat:**

- **Ha a rackben csak ez az egy készülék található, a rack aljába kell beszerelni.**
- **Ha nincs teljesen tele az a rack, amelybe beszerelik a készüléket, alulról fölfelé haladva töltse fel a racket úgy, hogy a legnehezebb készülék kerüljön a rack aljába.**
- **Ha stabilizáló eszközök is tartoznak a rackhez, szerelje fel a stabilizátorokat, mielőtt beszerelné az egységet a rackbe, vagy karbantartást végezne rajta.**

Предупреждение Во избежание травм при монтаже и обслуживании устройства в стойке следует принять особые меры предосторожности, чтобы убедиться в устойчивости оборудования.
Для обеспечения безопасности работ необходимо соблюдать следующие правила.

- Если в стойке находится одно устройство, оно должно быть установлено в нижней части.
- При монтаже устройств в частично заполненную стойку устанавливайте оборудование снизу вверх, размещая наиболее тяжелые устройства в нижней части.
- Если стойка снабжена приспособлениями для стабилизации, их необходимо установить до начала монтажа или обслуживания оборудования.

警告 为避免在机架中安装或维修该部件时使身体受伤，您必须采取特殊的预防措施确保系统固定。以下是确保安全的原则：

- 如果此部件是机架中唯一的部件，应将其安装在机架的底部。
- 如果在部分装满的机架中安装此部件，请按从下往上的顺序安装各个部件，并且最重的组件应安装在机架的底部。
- 如果机架配有固定装置，请先装好固定装置，然后再在机架中安装或维修部件。

警告 この装置をラックに設置したり保守作業を行ったりするときは、人身事故を防ぐため、システムが安定しているかどうかを十分に確認する必要があります。次の注意事項に従ってください。

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- ラックに安定器具が付属している場合は、その安定器具を取り付けてから、装置をラックに設置するか、またはラック内の装置の保守作業を行ってください。

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- 안정기가 랙과 함께 제공되는 경우, 이 안정기를 설치한 후 이 장치를 랙에 장착하거나 서비스하십시오

Aviso **Para evitar lesões corporais ao montar ou dar manutenção a esta unidade em um rack, é necessário tomar todas as precauções para garantir a estabilidade do sistema. As seguintes orientações são fornecidas para garantir a sua segurança:**

- **Se esta for a única unidade, ela deverá ser montada na parte inferior do rack.**
- **Ao montar esta unidade em um rack parcialmente preenchido, carregue-o de baixo para cima com o componente mais pesado em sua parte inferior.**
- **Se o rack contiver dispositivos estabilizadores, instale-os antes de montar ou dar manutenção à unidade existente.**

Advarsel **For at forhindre legemesbeskadigelse ved montering eller service af denne enhed i et rack, skal du sikre at systemet står stabilt. Følgende retningslinjer er også for din sikkerheds skyld:**

- **Enheden skal monteres i bunden af dit rack, hvis det er den eneste enhed i racket.**
- **Ved montering af denne enhed i et delvist fyldt rack, skal enhederne installeres fra bunden og opad med den tungeste enhed nederst.**
- **Hvis racket leveres med stabiliseringsenheder, skal disse installeres for enheden monteres eller serviceres i racket.**

تحذير

لتجنب حدوث أي إصابات عند تركيب هذه الوحدة، يجب اتباع بعض الاحتياطات لضمان عمل النظام بشكل سليم.
يتم ذكر الإرشادات التالية لضمان الأمان.
يجب تركيب هذه الوحدة في الجزء السفلي من الدولاب المتضمن قضبان إذا كانت هذه الوحدة هي الوحدة الوحيدة في الدولاب الذي يحتوي على قضبان.
عند تركيب هذه الوحدة في دولاب شبه ممتلئ، قم برفع الدولاب من الجزء السفلي لأعلى بحيث يكون الجزء الأثقل وزناً أسفل الدولاب.
إذا كان الدولاب المتضمن قضباناً يحتوي على أجهزة حفظ التوازن، قم بتثبيت هذه الأجهزة قبل تركيب الوحدة في الدولاب.

Upozorenje **Kako ne bi došlo do tjelesnih ozljeda kod postavljanja ili servisiranja uređaja na polici, potrebno je poduzeti mjere predostrožnosti kako bi sustav uvijek bio stabilan. Sigurnost se može osigurati poštivanjem sljedećih smjernica:**
- **Ovaj uređaj treba ugraditi na dno police, ukoliko je to jedini uređaj na polici.**
- **Kod ugradnje uređaja u policu na kojoj se već nalaze drugi uređaji, policu treba opremati počevši od dna, te tako da se na dno stave najteži dijelovi.**
- **Ukoliko su na polici ugrađeni stabilizatori, njih montirajte prije ugradnje ili servisiranja uređaja na polici.**

Upozornění **Abyste předešli poranění osob při montáži nebo opravě zařízení v montážním rámu, musíte dodržovat zvláštní preventivní opatření pro zajištění udržení stability systému. Pro zajištění bezpečnosti obsluhy jsou určeny následující zásady:**
- **Pokud je toto zařízení jedinou jednotkou v montážním rámu, musí být namontováno na nejnižší místo rámu.**
- **Pokud je toto zařízení montováno do částečně obsazeného montážního rámu, obsazujte montážní rám ve směru zdola nahoru tak, aby byla nejtěžší součást nejníže.**
- **Pokud je montážní rám vybaven stabilizačními zařízeními, nainstalujte stabilizátory ještě před montáží nebo opravou zařízení v montážním rámu.**

Προειδοποίηση Για να αποφύγετε τον τραυματισμό κατά την τοποθέτηση ή τη συντήρηση αυτής της συσκευής σε αρθρωτό σύστημα, πρέπει να λάβετε ειδικές προφυλάξεις για να διασφαλίσετε τη σταθερότητα του συστήματος. Οι παρακάτω οδηγίες παρέχονται για να εξασφαλίσουν την ασφάλειά σας:
- Αυτή η συσκευή πρέπει να τοποθετείται στο κάτω μέρος του αρθρωτού συστήματος αν είναι η μοναδική συσκευή σε αυτό.
- Όταν τοποθετείτε αυτήν τη συσκευή σε εν μέρει γεμάτο αρθρωτό σύστημα, τοποθετήστε συσκευές στο αρθρωτό σύστημα από κάτω προς τα επάνω, με τη βαρύτερη συσκευή στο κάτω μέρος του συστήματος.
- Εάν το αρθρωτό σύστημα διαθέτει διατάξεις σταθεροποίησης, τοποθετήστε τους σταθεροποιητές πριν τοποθετήσετε ή συντηρήσετε τη συσκευή στο αρθρωτό σύστημα.

אזהרה כדי למנוע פציעה בעת הרכבת יחידה זו במעמד או טיפול בה, עליך לנקוט אמצעי זהירות מיוחדים כדי להבטיח את יציבות המערכת. הקווים המנחים הבאים ניתנים על מנת להבטיח את ביטחונך:
- אם יחידה זו היא יחידה בודדת במעמד, יש להרכיב את היחידה בחלקו התחתון של המעמד.
- בעת הרכבת יחידה זו במעמד המלא בחלקו, טען את המעמד החל בחלק התחתון וכלפי מעלה כאשר הרכיב הכבד ביותר נמצא בחלקו התחתון של המעמד.
- אם המעמד מסופק עם התקני ייצוב, התקן את המייצבים לפני הרכבה היחידה במעמד או טיפול בה.

Opomena За да се не повредите кога го монтирате или го сервисирате уредот на полица, мора да бидете особено претпазливи за да ја обезбедите стабилноста на системот. Следите напатствија се дадени за да ја осигураат Вашата безбедност:
- Уредот треба да се монтира најдолу на полицата ако е единствен уред на полицата.
- Кога го монтирате уредот на делумно пополнета полица, полнете ја полицата од дното кон врвот со најтешката компонента на дното на полицата.
- Ако полицата има стабилизаторски делови, наместете ги стабилизаторите пред да го монтирате или сервисирате уредот на полицата.

Ostrzeżenie **Aby zapobiec urazom podczas montażu lub serwisowania tego urządzenia w stojaku, należy zastosować szczególne środki ostrożności w celu zapewnienia stabilności układu. Poniżej przedstawiono wskazówki, których przestrzeganie zapewni bezpieczeństwo:**

- **Jeśli urządzenie to jest jedynym urządzeniem w stojaku, powinno być zamontowane na dole.**
- **W przypadku montażu urządzenia w częściowo zapełnionym stojaku należy instalować kolejne urządzenia od najniższego do najwyższego, przy czym element najcięższy powinien być zamontowany najniżej w stojaku.**
- **Jeśli stojak jest wyposażony w elementy stabilizujące, należy zamontować stabilizatory przed przystąpieniem do montażu lub serwisowania urządzeń w stojaku.**

Upozornenie **Aby ste predišli poraneniu osôb pri montáži alebo oprave zariadenia v montážnom ráme, musíte dodržiavať zvláštne preventívne opatrenia na zaistenie udržania stability systému. Na zaistenie bezpečnosti obsluhy sú určené nasledujúce zásady:**

- **Pokiaľ je toto zariadenie jedinou jednotkou v montážnom ráme, musí byť namontované na najnižšie miesto v ráme.**
- **Pokiaľ je toto zariadenie montované do čiastočne obsadeného montážneho rámu, obsadzujte montážny rám v smere zdola nahor tak, aby bola najťažšia súčasť najnižšie.**
- **Pokiaľ je montážny rám vybavený stabilizačnými zariadeniami, nainštalujte stabilizátory ešte pred montážou alebo opravou zariadenia v montážnom ráme.**

Figyelem **A készülék rackbe történő beszerelése és karbantartása során bekövetkező sérülések elkerülése végett speciális óvintézkedésekkel meg kell őrizni a rendszer stabilitását. A személyes biztonsága érdekében tartsa be a következő szabályokat:**

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- 부분적으로 차 있는 랙에 이 장치를 장착할 경우, 가장 무거운 장치를 랙의 맨 아래 부분부터 차례로 장착하십시오.
- 안정기가 랙과 함께 제공되는 경우, 이 안정기를 설치한 후 이 장치를 랙에 장착하거나 서비스하십시오

تحذير **لتجنب حدوث أي إصابات عند تركيب هذه الوحدة، يجب اتباع بعض الاحتياطات لضمان عمل النظام بشكل سليم. يتم ذكر الإرشادات التالية لضمان الأمان.**

يجب تركيب هذه الوحدة في الجزء السفلي من الدولاب المتضمن قضبان إذا كانت هذه الوحدة هي الوحدة الوحيدة في الدولاب الذي يحتوي على قضبان.

عند تركيب هذه الوحدة في دولاب شبه ممتلئ، قم برفع الدولاب من الجزء السفلي لأعلى بحيث يكون الجزء الأثقل وزناً أسفل الدولاب.

إذا كان الدولاب المتضمن قضباناً يحتوي على أجهزة حفظ التوازن، قم بتثبيت هذه الأجهزة قبل تركيب الوحدة في الدولاب.

Upozorenje Kako ne bi došlo do tjelesnih ozljeda kod postavljanja ili servisiranja uređaja na polici, potrebno je poduzeti mjere predostrožnosti kako bi sustav uvijek bio stabilan. Sigurnost se može osigurati poštivanjem sljedećih smjernica:

- **Ovaj uređaj treba ugraditi na dno police, ukoliko je to jedini uređaj na polici.**
- **Kod ugradnje uređaja u policu na kojoj se već nalaze drugi uređaji, policu treba opremati počevši od dna, te tako da se na dno stave najteži dijelovi.**
- **Ukoliko su na polici ugrađeni stabilizatori, njih montirajte prije ugradnje ili servisiranja uređaja na polici.**

Upozornění Abyste předešli poranění osob při montáži nebo opravě zařízení v montážním rámu, musíte dodržovat zvláštní preventivní opatření pro zajištění udržení stability systému. Pro zajištění bezpečnosti obsluhy jsou určeny následující zásady:

- **Pokud je toto zařízení jedinou jednotkou v montážním rámu, musí být namontováno na nejnižší místo rámu.**
- **Pokud je toto zařízení montováno do částečně obsazeného montážního rámu, obsazujte montážní rám ve směru zdola nahoru tak, aby byla nejtěžší součást nejníže.**
- **Pokud je montážní rám vybaven stabilizačními zařízeními, nainstalujte stabilizátory ještě před montáží nebo opravou zařízení v montážním rámu.**

Προειδοποίηση

Για να αποφύγετε τον τραυματισμό κατά την τοποθέτηση ή τη συντήρηση αυτής της συσκευής σε αρθρωτό σύστημα, πρέπει να λάβετε ειδικές προφυλάξεις για να διασφαλίσετε τη σταθερότητα του συστήματος. Οι παρακάτω οδηγίες παρέχονται για να εξασφαλίσουν την ασφάλειά σας:

- Αυτή η συσκευή πρέπει να τοποθετείται στο κάτω μέρος του αρθρωτού συστήματος αν είναι η μοναδική συσκευή σε αυτό.
- Όταν τοποθετείτε αυτήν τη συσκευή σε εν μέρει γεμάτο αρθρωτό σύστημα, τοποθετήστε συσκευές στο αρθρωτό σύστημα από κάτω προς τα επάνω, με τη βαρύτερη συσκευή στο κάτω μέρος του συστήματος.
- Εάν το αρθρωτό σύστημα διαθέτει διατάξεις σταθεροποίησης, τοποθετήστε τους σταθεροποιητές πριν τοποθετήσετε ή συντηρήσετε τη συσκευή στο αρθρωτό σύστημα.

אזהרה

כדי למנוע פציעה בעת הרכבת יחידה זו במעמד או טיפול בה, עליך לנקוט אמצעי זהירות מיוחדים כדי להבטיח את יציבות המערכת. הקווים המנחים הבאים ניתנים על מנת להבטיח את ביטחונך:

- אם יחידה זו היא יחידה בודדת במעמד, יש להרכיב את היחידה בחלקו התחתון של המעמד.
- בעת הרכבת יחידה זו במעמד המלא בחלקו, טען את המעמד החל בחלק התחתון וכלפי מעלה כאשר הרכיב הכבד ביותר נמצא בחלקו התחתון של המעמד.
- אם המעמד מסופק עם התקני ייצוב, התקן את המייצבים לפני הרכבה היחידה במעמד או טיפול בה.

Opomena

За да се не повредите кога го монтирате или го сервисирате уредот на полица, мора да бидете особено претпазливи за да ја обезбедите стабилноста на системот. Следите напатствија се дадени за да ја осигураат Вашата безбедност:

- Уредот треба да се монтира најдолу на полицата ако е единствен уред на полицата.
- Кога го монтирате уредот на делумно пополнета полица, полнете ја полицата од дното кон врвот со најтешката компонента на дното на полицата.
- Ако полицата има стабилизаторски делови, наместете ги стабилизаторите пред да го монтирате или сервисирате уредот на полицата.

Ostrzeżenie **Aby zapobiec urazom podczas montażu lub serwisowania tego urządzenia w stojaku, należy zastosować szczególne środki ostrożności w celu zapewnienia stabilności układu. Poniżej przedstawiono wskazówki, których przestrzeganie zapewni bezpieczeństwo:**

- **Jeśli urządzenie to jest jedynym urządzeniem w stojaku, powinno być zamontowane na dole.**
- **W przypadku montażu urządzenia w częściowo zapełnionym stojaku należy instalować kolejne urządzenia od najniższego do najwyższego, przy czym element najcięższy powinien być zamontowany najniżej w stojaku.**
- **Jeśli stojak jest wyposażony w elementy stabilizujące, należy zamontować stabilizatory przed przystąpieniem do montażu lub serwisowania urządzeń w stojaku.**

Upozornenie **Aby ste predišli poraneniu osôb pri montáži alebo oprave zariadenia v montážnom ráme, musíte dodržiavať zvláštne preventívne opatrenia na zaistenie udržania stability systému. Na zaistenie bezpečnosti obsluhy sú určené nasledujúce zásady:**

- **Pokiaľ je toto zariadenie jedinou jednotkou v montážnom ráme, musí byť namontované na najnižšie miesto v ráme.**
- **Pokiaľ je toto zariadenie montované do čiastočne obsadeného montážneho rámu, obsadzujte montážny rám v smere zdola nahor tak, aby bola najťažšia súčasť najnižšie.**
- **Pokiaľ je montážny rám vybavený stabilizačnými zariadeniami, nainštalujte stabilizátory ešte pred montážou alebo opravou zariadenia v montážnom ráme.**

Battery Handling Warning for 4400 Series Controllers

Warning **There is the danger of explosion if the Cisco 4400 Series Wireless LAN Controller battery is replaced incorrectly. Replace the battery only with the same or equivalent type recommended by the manufacturer. Dispose of used batteries according to the manufacturer's instructions.** Statement 1015

Waarschuwing **Er is ontploffingsgevaar als de batterij verkeerd vervangen wordt. Vervang de batterij slechts met hetzelfde of een equivalent type dat door de fabrikant aanbevolen is. Gebruikte batterijen dienen overeenkomstig fabrieksvoorschriften weggeworpen te worden.**

Varoitus **Räjähdyksen vaara, jos akku on vaihdettu väärään akkuun. Käytä vaihtamiseen ainoastaan samantai vastaavantyyppistä akkua, joka on valmistajan suosittelema. Hävitä käytetyt akut valmistajan ohjeiden mukaan.**

Attention **Danger d'explosion si la pile n'est pas remplacée correctement. Ne la remplacer que par une pile de type semblable ou équivalent, recommandée par le fabricant. Jeter les piles usagées conformément aux instructions du fabricant.**

Warnung **Bei Einsetzen einer falschen Batterie besteht Explosionsgefahr. Ersetzen Sie die Batterie nur durch den gleichen oder vom Hersteller empfohlenen Batterietyp. Entsorgen Sie die benutzten Batterien nach den Anweisungen des Herstellers.**

Avvertenza **Pericolo di esplosione se la batteria non è installata correttamente. Sostituire solo con una di tipo uguale o equivalente, consigliata dal produttore. Eliminare le batterie usate secondo le istruzioni del produttore.**

Advarsel **Det kan være fare for eksplosjon hvis batteriet skiftes på feil måte. Skift kun med samme eller tilsvarende type som er anbefalt av produsenten. Kasser brukte batterier i henhold til produsentens instruksjoner.**

Aviso **Existe perigo de explosão se a bateria for substituída incorrectamente. Substitua a bateria por uma bateria igual ou de um tipo equivalente recomendado pelo fabricante. Destrua as baterias usadas conforme as instruções do fabricante.**

¡Advertencia! **Existe peligro de explosión si la batería se reemplaza de manera incorrecta. Reemplazar la batería exclusivamente con el mismo tipo o el equivalente recomendado por el fabricante. Desechar las baterías gastadas según las instrucciones del fabricante.**

Varning! **Explosionsfara vid felaktigt batteribyte. Ersätt endast batteriet med samma batterityp som rekommenderas av tillverkaren eller motsvarande. Följ tillverkarens anvisningar vid kassering av använda batterier.**

Figyelem **Robbanásveszélyt idézhet elő, ha helytelenül cserélik ki az akkumulátort. Csak a gyártó által javasolttal megegyező vagy azzal egyenértékű típusúra cserélje ki az akkumulátort! A használt akkumulátorok kidobásakor tartsa be a gyártó előírásait!**

Предупреждение При неправильной замене батареи возможен взрыв. Для замены следует использовать батарею того же или аналогичного типа, рекомендованного изготовителем. Утилизацию батареи необходимо производить в соответствии с указаниями изготовителя.

警告 电池更换不当会有爆炸危险。请只用同类电池或制造商推荐的功能相当的电池更换原有电池。请按制造商的说明处理废旧电池。

警告 不適切なバッテリに交換すると、爆発の危険性があります。製造元が推奨するものと同じまたは同等のバッテリだけを使用してください。使用済みのバッテリは、製造元が指示する方法に従って処分してください。

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Equipment Installation Warning

Warning **Only trained and qualified personnel should be allowed to install, replace, or service this equipment.** Statement 1030

Waarschuwing **Deze apparatuur mag alleen worden geïnstalleerd, vervangen of hersteld door bevoegd geschoold personeel.**

Varoitus **Tämän laitteen saa asentaa, vaihtaa tai huoltaa ainoastaan koulutettu ja laitteen tunteva henkilökunta.**

Attention **Il est vivement recommandé de confier l'installation, le remplacement et la maintenance de ces équipements à des personnels qualifiés et expérimentés.**

Warnung **Das Installieren, Ersetzen oder Bedienen dieser Ausrüstung sollte nur geschultem, qualifiziertem Personal gestattet werden.**

Avvertenza **Questo apparato può essere installato, sostituito o mantenuto unicamente da un personale competente.**

Advarsel **Bare opplært og kvalifisert personell skal foreta installasjoner, utskiftninger eller service på dette utstyret.**

Aviso **Apenas pessoal treinado e qualificado deve ser autorizado a instalar, substituir ou fazer a revisão deste equipamento.**

¡Advertencia! **Solamente el personal calificado debe instalar, reemplazar o utilizar este equipo.**

Varning! **Endast utbildad och kvalificerad personal bör få tillåtelse att installera, byta ut eller reparera denna utrustning.**

Figyelem **A berendezést csak szakképzett személyek helyezhetik üzembe, cserélhetik és tarthatják karban.**

Предупреждение Установку, замену и обслуживание этого оборудования может осуществлять только специально обученный квалифицированный персонал.

警告 只有经过培训且具有资格的人员才能进行此设备的安装、更换和维修。

警告 この装置の設置、交換、保守は、訓練を受けた相応の資格のある人が行ってください。

주의 교육을 받고 자격을 갖춘 사람만 이 장비를 설치, 교체, 또는 서비스를 수행해야 합니다.

Aviso **Somente uma equipe treinada e qualificada tem permissão para instalar, substituir ou dar manutenção a este equipamento.**

Advarsel **Kun uddannede personer må installere, udskifte komponenter i eller servicere dette udstyr.**

تحذير يسمح للفنيين المتخصصين فقط بتركيب المعدة أو استبدالها أو إجراء الصيانة عليها.

Upozorenje **Uređaj smije ugrađivati, mijenjati i servisirati samo za to obučeno i osposobljeno servisno osoblje.**

Upozornění **Instalaci, výměnu nebo opravu tohoto zařízení smějí provádět pouze proškolené a kvalifikované osoby.**

Προειδοποίηση Η τοποθέτηση, η αντικατάσταση και η συντήρηση του εξοπλισμού επιτρέπεται να γίνονται μόνο από καταρτισμένο προσωπικό με τα κατάλληλα προσόντα.

אזהרה רק עובדים מיומנים ומוסמכים רשאים להתקין, להחליף, או לטפל בציד זה.

Opomena Местењето, заменувањето и сервисирањето на оваа опрема треба да му биде дозволено само на обучен и квалификуван персонал.

Ostrzeżenie **Do instalacji, wymiany i serwisowania tych urządzeń mogą być dopuszczone wyłącznie osoby wykwalifikowane i przeszkolone.**

Upozornenie **Inštaláciu, výmenu alebo opravu tohto zariadenia smú vykonávať iba vyškolené a kvalifikované osoby.**

Figyelem **A berendezést csak szakképzett személyek helyezhetik üzembe, cserélhetik és tarthatják karban.**

Предупреждение Установку, замену и обслуживание этого оборудования может осуществлять только специально обученный квалифицированный персонал.

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주의 교육을 받고 자격을 갖춘 사람만 이 장비를 설치, 교체, 또는 서비스를 수행해야 합니다.

تحذير يسمح للفنيين المتخصصين فقط بتركيب المعدة أو استبدالها أو إجراء الصيانة عليها.

Upozorenje **Uređaj smije ugrađivati, mijenjati i servisirati samo za to obučeno i osposobljeno servisno osoblje.**

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Upozornenie Inštaláciu, výmenu alebo opravu tohto zariadenia smú vykonávať iba vyškolené a kvalifikované osoby.

More Than One Power Supply Warning for 4400 Series Controllers

Warning **The Cisco 4400 Series Wireless LAN Controller might have more than one power supply connection. All connections must be removed to de-energize the unit.** Statement 1028

Waarschuwing **Deze eenheid kan meer dan één stroomtoevoeraansluiting bevatten. Alle aansluitingen dienen ontkoppeld te worden om de eenheid te ontkrachten.**

Varoitus **Tässä laitteessa voi olla useampia kuin yksi virtakytkentä. Kaikki liitännät on irrotettava, jotta jännite poistetaan laitteesta.**

Attention **Cette unité peut avoir plus d'une connexion d'alimentation. Pour supprimer toute tension et tout courant électrique de l'unité, toutes les connexions d'alimentation doivent être débranchées.**

Warnung **Dieses Gerät kann mehr als eine Stromzufuhr haben. Um sicherzustellen, dass der Einheit kein Strom zugeführt wird, müssen alle Verbindungen entfernt werden.**

Avvertenza **Questa unità può avere più di una connessione all'alimentazione elettrica. Tutte le connessioni devono essere staccate per togliere la corrente dall'unità.**

Advarsel **Denne enheten kan ha mer enn én strømtilførselskobling. Alle koblinger må fjernes fra enheten for å utkoble all strøm.**

Aviso **Esta unidade poderá ter mais de uma conexão de fonte de energia. Todas as conexões devem ser removidas para desligar a unidade.**

¡Advertencia! **Puede que esta unidad tenga más de una conexión para fuentes de alimentación. Para cortar por completo el suministro de energía, deben desconectarse todas las conexiones.**

Varning! **Denna enhet har eventuellt mer än en strömförsörjningsanslutning. Alla anslutningar måste tas bort för att göra enheten strömlös.**

Figyelem **Előfordulhat, hogy a készülék többszörösen van csatlakoztatva az áramforráshoz. A készülék áramtalanításához mindegyik csatlakozást meg kell szüntetni.**

Предупреждение В данном устройстве может использоваться несколько подключений к электросети. Чтобы обесточить устройство, необходимо отключить все эти подключения.

警告 此部件连接的电源可能不止一个。必须将所有电源断开才能停止给该部件供电。

警告 この装置には、複数の電源が接続されている場合があります。装置の電源を完全にオフにするには、すべての電源を切断する必要があります。

주의 본 장치에는 2개 이상의 전원 공급 연결 단자가 있을 수 있습니다. 이 장치의 전원을 차단하려면 모든 연결 단자를 제거해야 합니다.

Aviso **Esta unidade pode ter mais de uma conexão de fonte de alimentação. Todas as conexões devem ser removidas para interromper a alimentação da unidade.**

Advarsel **Denne enhed har muligvis mere end en strømforsyningstilslutning. Alle tilslutninger skal fjernes for at aflade strømmen fra enheden.**

تحذير **قد تتضمن هذه الوحدة أكثر من اتصال بمورد الطاقة. يجب فصل كافة التوصيلات حتى يمكن إفراغ طاقة الوحدة.**

Upozorenje **Uređaj može imati više priključaka za izvore napajanja. Za potpuno isključivanje napajanja potrebno je iskopčati sve priključke.**

Upozornění **Toto zařízení může být připojeno k více než jednomu zdroji napájení. Aby se zařízení zcela odpojilo od proudu, musí být odpojeno od všech zdrojů napájení.**

Προειδοποίηση Αυτή η συσκευή ίσως να έχει περισσότερες συνδέσεις τροφοδοσίας.
Για να απενεργοποιηθεί η συσκευή, πρέπει να αφαιρεθούν όλες οι συνδέσεις.

אזהרה ייתכן שביחידה זו קיים יותר מחיבור אחד לספק כוח. יש להסיר את כל החיבורים כדי להפסיק את אספקת המתח ליחידה.

Opomena Уредот може да има повеќе од еден приклучок за напојување. Сите приклучоци мора да се извадат за да се прекине доводот на енергија во уредот.

Ostrzeżenie **To urządzenie może mieć podłączone więcej niż jedno źródło zasilania. Aby całkowicie odciąć dopływ energii do urządzenia, należy odłączyć wszystkie źródła zasilania.**

Upozornenie **Toto zariadenie môže byť pripojené k viac ako jednému zdroju napájania. Aby sa zariadenie odpojilo od prúdu, musí byť odpojené od všetkých zdrojov.**

Figyelem **Előfordulhat, hogy a készülék többszörösen van csatlakoztatva az áramforráshoz. A készülék áramtalanításához mindegyik csatlakozást meg kell szüntetni.**

Предупреждение В данном устройстве может использоваться несколько подключений к электросети. Чтобы обесточить устройство, необходимо отключить все эти подключения.

警告 此部件连接的电源可能不止一个。必须将所有电源断开才能停止给该部件供电。

警告 この装置には、複数の電源が接続されている場合があります。装置の電源を完全にオフにするには、すべての電源を切断する必要があります。

주의 본 장치에는 2개 이상의 전원 공급 연결 단자가 있을 수 있습니다. 이 장치의 전원을 차단하려면 모든 연결 단자를 제거해야 합니다.

تحذير قد تتضمن هذه الوحدة أكثر من اتصال بمورد الطاقة. يجب فصل كافة التوصيلات حتى يمكن إفراغ طاقة الوحدة.

Upozorenje **Uređaj može imati više priključaka za izvore napajanja. Za potpuno isključivanje napajanja potrebno je iskopčati sve priključke.**

Upozornění **Toto zařízení může být připojeno k více než jednomu zdroji napájení. Aby se zařízení zcela odpojilo od proudu, musí být odpojeno od všech zdrojů napájení.**

Προειδοποίηση Αυτή η συσκευή ίσως να έχει περισσότερες συνδέσεις τροφοδοσίας. Για να απενεργοποιηθεί η συσκευή, πρέπει να αφαιρεθούν όλες οι συνδέσεις.

אזהרה ייתכן שביחידה זו קיים יותר מחיבור אחד לספק כוח. יש להסיר את כל החיבורים כדי להפסיק את אספקת המתח ליחידה.

Opomena Уредот може да има повеќе од еден приклучок за напојување. Сите приклучоци мора да се извадат за да се прекине доводот на енергија во уредот.

Ostrzeżenie **To urządzenie może mieć podłączone więcej niż jedno źródło zasilania. Aby całkowicie odciąć dopływ energii do urządzenia, należy odłączyć wszystkie źródła zasilania.**

Upozornenie **Toto zariadenie môže byť pripojené k viac ako jednému zdroju napájania. Aby sa zariadenie odpojilo od prúdu, musí byť odpojené od všetkých zdrojov.**

Declarations of Conformity and Regulatory Information

This appendix provides declarations of conformity and regulatory information for the products in the Cisco Unified Wireless Network Solution.

This appendix contains these sections:

Regulatory Information for 1000 Series Access Points

This section contains regulatory information for 1000 series access points. The information is in these sections:

Manufacturers Federal Communication Commission Declaration of Conformity Statement

Model:

AIR-AP1010-A-K9, AIR-AP1020-A-K9, AIR-AP1030-A-K9

FCC Certification number:

LDK102057

Manufacturer:

Cisco Systems, Inc.
170 West Tasman Drive
San Jose, CA 95134-1706
USA

This device complies with Part 15 rules. Operation is subject to the following two conditions:

1. This device may not cause harmful interference, and
2. This device must accept any interference received, including interference that may cause undesired operation.

This equipment has been tested and found to comply with the limits of a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a residential environment. This equipment generates, uses, and radiates radio frequency energy, and if not installed and used in accordance with the instructions, may cause harmful interference. However, there is no guarantee that interference will not

occur. If this equipment does cause interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to correct the interference by one of the following measures:

- Reorient or relocate the receiving antenna.
- Increase separation between the equipment and receiver.
- Connect the equipment to an outlet on a circuit different from which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician.

Caution The Part 15 radio device operates on a non-interference basis with other devices operating at this frequency when using the integrated antennas. Any changes or modification to the product not expressly approved by Cisco could void the user's authority to operate this device.

Caution Within the 5.15 to 5.25 GHz band (5 GHz radio channels 34 to 48) the U-NII devices are restricted to indoor operations to reduce any potential for harmful interference to co-channel Mobile Satellite System (MSS) operations.

Department of Communications—Canada

Model:

AIR-AP1010-A-K9, AIR-AP1020-A-K9, AIR-AP1030-A-K9

Certification number:

2461B-102057

Canadian Compliance Statement

This Class B Digital apparatus meets all the requirements of the Canadian Interference-Causing Equipment Regulations.

Cet appareil numerique de la classe B respecte les exigences du Reglement sur le material broilleur du Canada.

This device complies with Class B Limits of Industry Canada. Operation is subject to the following two conditions:

1. This device may not cause harmful interference, and
2. This device must accept any interference received, including interference that may cause undesired operation.

Cisco Aironet 2.4-GHz Access Points are certified to the requirements of RSS-210 for 2.4-GHz spread spectrum devices, and Cisco Aironet 54-Mbps, 5-GHz Access Points are certified to the requirements of RSS-210 for 5-GHz spread spectrum devices.The use of this device in a system operating either partially or completely outdoors may require the user to obtain a license for the system according to the Canadian regulations. For further information, contact your local Industry Canada office.

European Community, Switzerland, Norway, Iceland, and Liechtenstein

Model:

AIR-AP1010-E-K9, AIR-AP1020-E-K9, AIR-AP1030-E-K9

Declaration of Conformity with Regard to the R&TTE Directive 1999/5/EC

English:	This equipment is in compliance with the essential requirements and other relevant provisions of Directive 1999/5/EC.
Deutsch:	Dieses Gerät entspricht den grundlegenden Anforderungen und den weiteren entsprecheneden Vorgaben der Richtlinie 1999/5/EU.
Dansk:	Dette udstyr er i overensstemmelse med de væsentlige krav og andre relevante bestemmelser i Directiv 1999/5/EF.
Español:	Este equipo cumple con los requisitos esenciales asi como con otras disposiciones de la Directive 1999/5/EC.
Έλληνας:	Αυτός ο εξοπλισμός συμμορφώνεται με τις ουσιώδεις απαιτήσεις και τις λοιπές διατάξεις της Οδηγίας 1999/5/ΕΚ.
Français:	Cet appareil est conforme aux exigencies essentialles et aux autres dispositions pertinantes de la Directive 1999/5/EC.
Íslenska:	Þessi búnaður samrýmist lögboðnum kröfum og öðrum ákvæðum tilskipunar 1999/5/ESB.
Italiano:	Questo apparato é conforme ai requisiti essenziali ed agli altri principi sanciti dalla Direttiva 1999/5/EC.
Nederlands:	Deze apparatuur voldoet aan de belangrijkste eisen en andere voorzieningen van richtlijn 1999/5/EC.
Norsk:	Dette utstyret er i samsvar med de grunnleggende krav og andre relevante bestemmelser i EU-directiv 1999/5/EC.
Português:	Este equipamento satisfaz os requisitos essenciais e outras provisões da Directiva 1999/5/EC.
Suomalainen:	Tämä laite täyttää direktiivin 1999/5/EY oleelliset vaatimukset ja on siinä asetettujen muidenkin ehtojen mukainen.
Svenska:	Denna utrustning är i överensstämmelse med de väsentliga kraven och andra relevanta bestämmelser i Direktiv 1999/5/EC.

For 2.4 GHz radios, the following standards were applied:

- Radio: EN 300.328-1, EN 300.328-2
- EMC: EN 301.489-1, EN 301.489-17
- Safety: EN 60950

Note This equipment is intended to be used in all EU and EFTA countries. Outdoor use may be restricted to certain frequencies and/or may require a license for operation. For more details, contact Cisco Corporate Compliance.

For 54 Mbps, 5 GHz access points, the following standards were applied:

- Radio: EN 301.893
- EMC: EN 301.489-1, EN 301.489-17
- Safety: EN 60950

The following CE mark is affixed to the access point with a 2.4 GHz radio and a 54 Mbps, 5 GHz radio:

Declaration of Conformity for RF Exposure

The radio has been found to be compliant to the requirements set forth in CFR 47 Sections 2.1091, and 15.247 (b) (4) addressing RF Exposure from radio frequency devices as defined in Evaluating Compliance with FCC Guidelines for Human Exposure to Radio Frequency Electromagnetic Fields. The equipment should be installed more than 20 cm (7.9 in.) from your body or nearby persons.

The access point must be installed to maintain a minimum 20 cm (7.9 in.) co-located separation distance from other FCC approved indoor/outdoor antennas used with the access point. Any antennas or transmitters not approved by the FCC cannot be co-located with the access point. The access point's co-located 2.4 GHz and 5 GHz integrated antennas support a minimum separation distance of 8 cm (3.2 in.) and are compliant with the applicable FCC RF exposure limit when transmitting simultaneously.

Note Dual antennas used for diversity operation are not considered co-located.

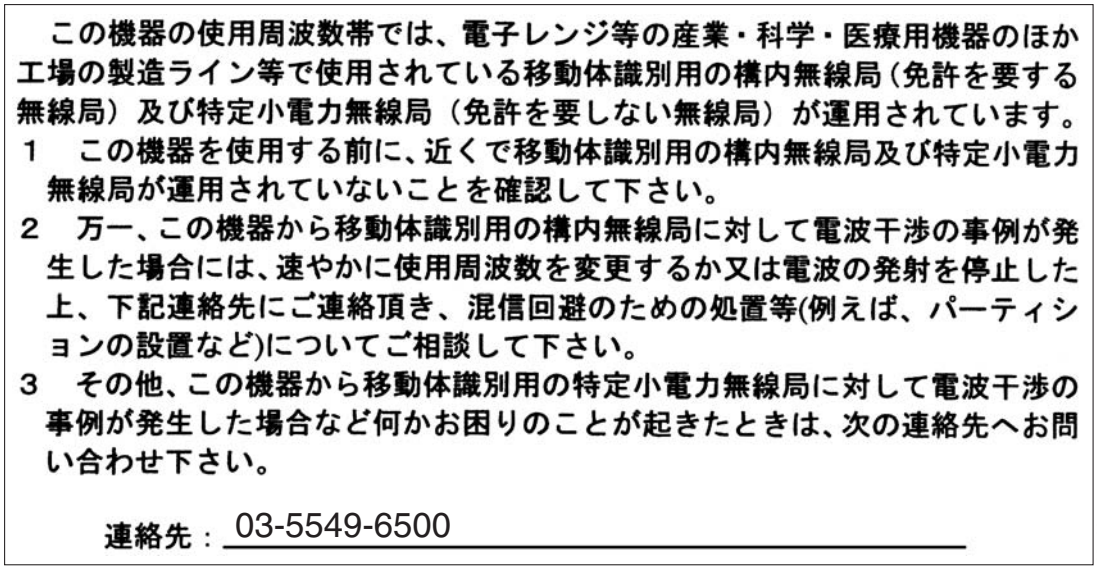
Guidelines for Operating Cisco Aironet Access Points in Japan

This section provides guidelines for avoiding interference when operating Cisco Aironet access points in Japan. These guidelines are provided in both Japanese and English.

Model:

AIR-AP1010-J-K9, AIR-AP1020-J-K9, AIR-AP1030-J-K9

Japanese Translation



English Translation

This equipment operates in the same frequency bandwidth as industrial, scientific, and medical devices such as microwave ovens and mobile object identification (RF-ID) systems (licensed premises radio stations and unlicensed specified low-power radio stations) used in factory production lines.

1. Before using this equipment, make sure that no premises radio stations or specified low-power radio stations of RF-ID are used in the vicinity.
2. If this equipment causes RF interference to a premises radio station of RF-ID, promptly change the frequency or stop using the device; contact the number below and ask for recommendations on avoiding radio interference, such as setting partitions.
3. If this equipment causes RF interference to a specified low-power radio station of RF-ID, contact the number below.

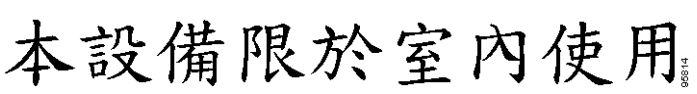
   Contact Number: 03-5549-6500

Administrative Rules for Cisco Aironet Access Points in Taiwan

This section provides administrative rules for operating Cisco Aironet access points in Taiwan. The rules are provided in both Chinese and English.

Access Points with IEEE 802.11a Radios

Chinese Translation

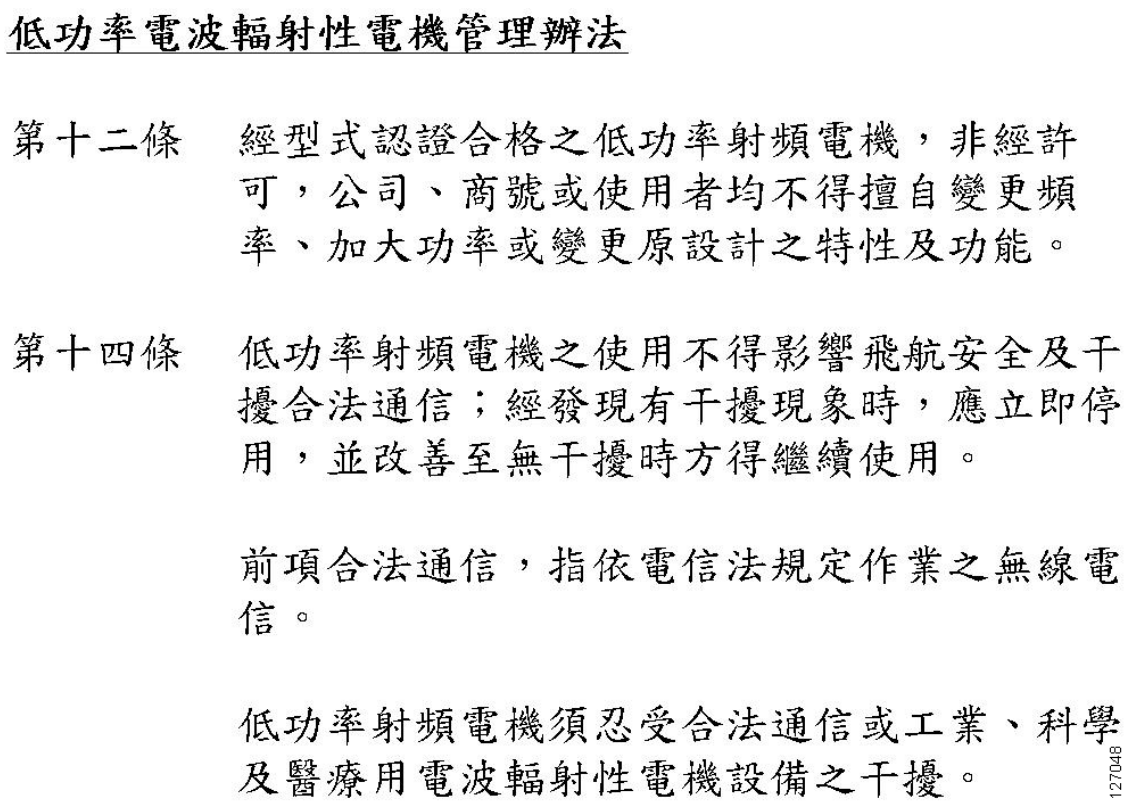


English Translation

This equipment is limited for indoor use.

All Access Points

Chinese Translation



English Translation

Administrative Rules for Low-power Radio-Frequency Devices

Article 12

For those low-power radio-frequency devices that have already received a type-approval, companies, business units or users should not change its frequencies, increase its power or change its original features and functions.

Article 14

The operation of the low-power radio-frequency devices is subject to the conditions that no harmful interference is caused to aviation safety and authorized radio station; and if interference is caused, the user must stop operating the device immediately and can't re-operate it until the harmful interference is clear.

The authorized radio station means a radio-communication service operating in accordance with the Communication Act.

The operation of the low-power radio-frequency devices is subject to the interference caused by the operation of an authorized radio station, by another intentional or unintentional radiator, by industrial, scientific and medical (ISM) equipment, or by an incidental radiator.

Declaration of Conformity Statements

All the Declaration of Conformity statements related to this product can be found at the following URL:

http://www.ciscofax.com

FCC Statements for Cisco 2000 Series Wireless LAN Controllers

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help. [cfr reference 15.105]

FCC Statements for Cisco 4100 Series Wireless LAN Controllers and Cisco 4400 Series Wireless LAN Controllers

FCC Statements for Cisco 4100 Series Wireless LAN Controllers and Cisco 4400 Series Wireless LAN Controllers

The Cisco 4100 Series Wireless LAN Controller and Cisco 4400 Series Wireless LAN Controller equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

End User License and Warranty

This appendix describes the end user license and warranty that apply to the Cisco Unified Wireless Network Solution products:

- Cisco 1000 Series Lightweight Access Points
- Cisco 2000 Series Wireless LAN Controllers
- Cisco 2700 Series Location Appliances
- Cisco 4100 Series Wireless LAN Controllers
- Cisco 4400 Series Wireless LAN Controllers
- Cisco Wireless Services Modules

This appendix contains these sections:

End User License Agreement

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(iv) use or permit the Software to be used to perform services for third parties, whether on a service bureau or time sharing basis or otherwise, without the express written authorization of Cisco; or

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Customer Records. Customer grants to Cisco and its independent accountants the right to examine Customer's books, records and accounts during Customer's normal business hours to verify compliance with this Agreement. In the event such audit discloses non-compliance with this Agreement, Customer shall promptly pay to Cisco the appropriate license fees, plus the reasonable cost of conducting the audit.

Export. Software and Documentation, including technical data, may be subject to U.S. export control laws, including the U.S. Export Administration Act and its associated regulations, and may be subject to export or import regulations in other countries. Customer agrees to comply strictly with all such regulations and acknowledges that it has the responsibility to obtain licenses to export, re-export, or import Software and Documentation. Customer's failure to comply with such restrictions shall constitute a material breach of the Agreement.

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Limited Warranty

Hardware for 1000 Series Access Points. Cisco Systems, Inc., or the Cisco Systems, Inc. subsidiary selling the Product ("Cisco") warrants that commencing from the date of shipment to Customer (and in case of resale by a Cisco reseller, commencing not more than ninety (90) days after original shipment by Cisco), and continuing for a period of one (1) year, the Hardware will be free from defects in material and workmanship under normal use. The date of shipment of a Product by Cisco is set forth on the packaging material in which the Product is shipped. This limited warranty extends only to the original user of the Product. Customer's sole and exclusive remedy and the entire liability of Cisco and its suppliers under this limited warranty will be, at Cisco's or its service center's option, shipment of a replacement within the warranty period and according to the replacement process described in the Warranty Card (if any), or if no Warranty Card, as described at *www.cisco.com/en/US/products/prod_warranties_listing.html* or a refund of the purchase price if the Hardware is returned to the party supplying it to Customer, freight and insurance prepaid. Cisco

replacement parts used in Hardware replacement may be new or equivalent to new. Cisco's obligations hereunder are conditioned upon the return of affected Hardware in accordance with Cisco's or its service center's then-current Return Material Authorization (RMA) procedures.

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System Messages and Access Point LED Patterns

This appendix lists system messages that can appear on the Cisco Unified Wireless Network Solution interfaces and describes the LED patterns on lightweight access points. It contains these sections:

System Messages

Table D-1 lists system messages and descriptions.

Table D-1 System Messages and Descriptions

Error Message	Description
STATION_DISASSOCIATE	Client may have intentionally terminated usage or may have experienced a service disruption.
STATION_DEAUTHENTICATE	Client may have intentionally terminated usage or it could indicate an authentication issue.
STATION_AUTHENTICATION_FAIL	Check disable, key mismatch or other configuration issues.
STATION_ASSOCIATE_FAIL	Check load on the Cisco Radio or signal quality issues.
LRAD_ASSOCIATED	The associated Cisco 1000 Series lightweight access point is now managed by this Cisco Wireless LAN Controller.
LRAD_DISASSOCIATED	Cisco 1000 Series lightweight access point may have associated with a different Cisco Wireless LAN Controller or may have become completely unreachable.
LRAD_UP	Cisco 1000 Series lightweight access point is operational, no action required.
LRAD_DOWN	Cisco 1000 Series lightweight access point may have a problem or is administratively disabled.
LRADIF_UP	Cisco Radio is UP.
LRADIF_DOWN	Cisco Radio may have a problem or is administratively disabled.
LRADIF_LOAD_PROFILE_FAILED	Client density may have exceeded system capacity.
LRADIF_NOISE_PROFILE_FAILED	The non-802.11 noise has exceed configured threshold.
LRADIF_INTERFERENCE_PROFILE_FAILED	802.11 interference has exceeded threshold on channel -- check channel assignments.
LRADIF_COVERAGE_PROFILE_FAILED	Possible coverage hole detected - check Cisco 1000 Series lightweight access point history to see if common problem - add Cisco 1000 Series lightweight access points if necessary.
LRADIF_LOAD_PROFILE_PASSED	Load is now within threshold limits.
LRADIF_NOISE_PROFILE_PASSED	Detected noise is now less than threshold.
LRADIF_INTERFERENCE_PROFILE_PASSED	Detected interference is now less than threshold.
LRADIF_COVERAGE_PROFILE_PASSED	Number of clients receiving poor signal are within threshold.
LRADIF_CURRENT_TXPOWER_CHANGED	Informational message.

Table D-1 System Messages and Descriptions (continued)

Error Message	Description
LRADIF_CURRENT_CHANNEL_CHANGED	Informational message.
LRADIF_RTS_THRESHOLD_CHANGED	Informational message.
LRADIF_ED_THRESHOLD_CHANGED	Informational message.
LRADIF_FRAGMENTATION_THRESHOLD_ CHANGED	Informational message.
RRM_DOT11_A_GROUPING_DONE	Informational message.
RRM_DOT11_B_GROUPING_DONE	Informational message.
ROGUE_AP_DETECTED	May be a security issue.Use maps and trends to investigate.
ROGUE_AP_REMOVED	Detected rogue access point has timed out. The unit might have shut down or moved out of the coverage area.
AP_MAX_ROGUE_COUNT_EXCEEDED	The current number of active rogue access points has exceeded system threshold.
LINK_UP	Positive confirmation message.
LINK_DOWN	Port may have a problem or is administratively disabled.
LINK_FAILURE	Port may have a problem or is administratively disabled.
AUTHENTICATION_FAILURE	Attempted security breech. Investigate.
STP_NEWROOT	Informational message.
STP_TOPOLOGY_CHANGE	Informational message.
IPSEC_ESP_AUTH_FAILURE	Check WLAN IPSec configuration.
IPSEC_ESP_REPLAY_FAILURE	Check for attempt to spoof IP Address.
IPSEC_ESP_POLICY_FAILURE	Check for IPSec configuration mismatch between WLAN and client.
IPSEC_ESP_INVALID_SPI	Informational message.
IPSEC_OTHER_POLICY_FAILURE	Check for IPSec configuration mismatch between WLAN and client.
IPSEC_IKE_NEG_FAILURE	Check for IPSec IKE configuration mismatch between WLAN and client.
IPSEC_SUITE_NEG_FAILURE	Check for IPSec IKE configuration mismatch between WLAN and client.
IPSEC_INVALID_COOKIE	Informational message.
RADIOS_EXCEEDED	Maximum number of supported Cisco Radios exceeded. Check for controller failure in the same Layer 2 network or add another controller.
SENSED_TEMPERATURE_HIGH	Check fan, air conditioning and/or other cooling arrangements.

Table D-1 System Messages and Descriptions (continued)

Error Message	Description
SENSED_TEMPERATURE_LOW	Check room temperature and/or other reasons for low temperature.
TEMPERATURE_SENSOR_FAILURE	Replace temperature sensor ASAP.
TEMPERATURE_SENSOR_CLEAR	Temperature sensor is operational.
POE_CONTROLLER_FAILURE	Check ports — possible serious failure detected.
MAX_ROGUE_COUNT_EXCEEDED	The current number of active rogue access points has exceeded system threshold.
SWITCH_UP	Controller is responding to SNMP polls.
SWITCH_DOWN	Controller is not responding to SNMP polls, check controller and SNMP settings.
RADIUS_SERVERS_FAILED	Check network connectivity between RADIUS and the controller.
CONFIG_SAVED	Running configuration has been saved to flash - will be active after reboot.
MULTIPLE_USERS	Another user with the same username has logged in.
FAN_FAILURE	Monitor Cisco Wireless LAN Controller temperature to avoid overheating.
POWER_SUPPLY_CHANGE	Check for power-supply malfunction.
COLD_START	Cisco Wireless LAN Controller may have been rebooted.
WARM_START	Cisco Wireless LAN Controller may have been rebooted.

Using Client Reason and Status Codes in Trap Logs

The WCS Clients > Detail page lists the reason and status codes that you are likely to encounter when reviewing the trap logs. Table D-2 lists client reason codes and descriptions. Table y lists client status codes and descriptions.

Client Reason Codes

This table lists client reason codes.

Table D-2 Client Reason Code Descriptions and Meanings

Client Reason Code	Description	Meaning
0	noReasonCode	Normal operation.
1	unspecifiedReason	Client associated but no longer authorized.

Table D-2 Client Reason Code Descriptions and Meanings (continued)

Client Reason Code	Description	Meaning
2	previousAuthNotValid	Client associated but not authorized.
3	deauthenticationLeaving	The access point went offline, deauthenticating the client.
4	disassociationDueToInactivity	Client session timeout exceeded.
5	disassociationAPBusy	The access point is busy, performing load balancing, for example.
6	class2FrameFromNonAuthStation	Client attempted to transfer data before it was authenticated.
7	class2FrameFromNonAssStation	Client attempted to transfer data before it was associated.
8	disassociationStaHasLeft	Operating System moved the client to another access point using non-aggressive load balancing.
9	staReqAssociationWithoutAuth	Client not authorized yet, still attempting to associate with an access point.
99	missingReasonCode	Client momentarily in an unknown state.

Client Status Codes

This table lists client status codes.

Table D-3 Client Status Code Descriptions and Meanings

Client Status Code	Description	Meaning
0	idle	Normal operation — no rejections of client association requests.
1	aaaPending	Completing an AAA transaction.
2	authenticated	802.11 authentication completed.
3	associated	802.11 association completed.
4	powersave	Client in powersave mode.
5	disassociated	802.11 disassociation completed.
6	tobedeleted	To be deleted after disassociation.
7	probing	Client not associated or authorized yet.
8	disabled	Automatically disabled by Operating System for an operator-defined time.

Using Lightweight Access Point LEDs

This table describes the meaning of LED patterns on lightweight access points.

Table D-4 Cisco 1000 Series Lightweight Access Point LED Conditions and Status

LED Conditions				
Power	**Alarm**	**2.4 GHz**	**5 GHz**	**Status**
Green on	off	on or off	on or off	Controller found, code OK, normal status.
Green on	off	Yellow on	on or off	802.11b/g activity.
Green on	off	on or off	Amber on	802.11a activity.
off	Red on	off	off	Lightweight access point starting up.
All LEDs cycle back and forth				Lightweight access point searching for controller. Stops when controller and DHCP server are found.
All LEDs blink on and off together				Controller found, code upgrade in process.
off	Red flashing	off	off	Duplicate lightweight access point IP address.

Numerics

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